UPPER LLANDOVERY TRILOBITES FROM THE PENTLAND HILLS, SCOTLAND

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ABSTRACT. Well-preserved trilobites of Upper Llandovery age are reported from two of the three Silurian inliers in the Pentland Hills. In addition to two species of Phacopina previously described, there are some fifteen species belonging to Proetidae, Aulacopleuridae, Harpetidae, Cheiruridae, Encrinuridae, Calymenidae, Odontopleuridae, and Lichidae. In the older beds (Reservoir and Deerhope formations) trilobites are relatively rare and appear to be endemic to the Midland Valley of Scotland. In the succeeding lower part of the Wether Law Linn Formation the more abundant trilobites occur together with a rich brachiopod fauna and bear pronounced affinities with trilobites from the East Baltic. The hypostome of *Acernaspis* (*Eskaspis*) *sufferta* (Lamont) is described for the first time. New taxa described are *Cyphoproetus comitilis* n. sp. and *Harpidella* (*Harpidella*) *thomasi* n. sp.

SOUTH-WEST of Edinburgh, the Pentland Hills form an elevated chain some 35 km long, consisting mainly of Old Red Sandstone sediments and volcanics, and rising to a maximum height of about 600 m. The Old Red Sandstone rests unconformably upon almost vertical Silurian sediments, exposed in three inliers (text-fig. 1) (Mykura and Smith 1962; Tipper 1975, 1976). The largest and most westerly of these is the North Esk Inlier, within which are exposed Upper Llandovery marine sandstones and siltstones, passing up into a non-marine redbed sequence of Wenlock age. This latter is similar in facies to the overlying Lower Old Red Sandstone, but is separated from it by a pronounced angular unconformity. The Upper Llandovery beds are very fossiliferous in places, and the preservation is excellent, as has long been known; Geikie (1924) relates how he first discovered fossils therein and Haswell (1865) wrote that 'most of the eminent geologists with whom I have been corresponding . . . were quite astonished at their fossiliferous character'.

Many of the fossils are still undescribed, or have been figured only as photographs and sketches (Lamont 1948, 1965, 1978). Most of the trilobites described in the present work are from the highly fossiliferous Deerhope and Wether Law Linn Formations of the North Esk Inlier, of which a geological summary has been given by Mykura and Smith (1962), and Tipper (1975, 1976). Descriptions of the phacopid trilobites from the North Esk Inlier have already been presented as the first part of this study and a historical and geological summary given in Clarkson, Eldredge and Henry (1977). The Bavelaw Inlier consists of poorly fossiliferous pale-green mudstones but contains, in addition to a few inarticulate brachiopods, finely preserved specimens of *Leonaspis lothiana* (Lamont). Very little fossiliferous material is preserved in the Loganlee-Craigenterrie Inlier, where the lithology is similar.

Of the four formations defined by Tipper (1976) in the North Esk Inlier, the lower part of the Reservoir Formation is very patchily fossiliferous, other than the beds containing starfish (Spencer 1914–40) and eurypterids (Waterston 1979) and has yielded only a few indeterminate *Acernaspis* and *Encrinurus* specimens along the Gutterford Burn. The upper part of the Reservoir Formation has more fossils, chonetid brachiopods and bivalves (Lamont 1954) being especially common, and there is a highly productive coral bed (NT 147580), from which very rich coral-brachiopod faunas as well as *Proetus* (s.l.) cf. *latifrons* were obtained by S. D. G. Campbell in 1976 and 1977. Trilobites are relatively rare, but when found may be complete. Several well-localized specimens, in variable preservation (*Acernaspis*, *Encrinurus*, *Harpidella thomasi* n. sp.), were found by Peach, Horne, and McConochie at localities along the Deerhope Burn, below the coral bed, and are in the collections of the Institute of Geological Sciences, Edinburgh.

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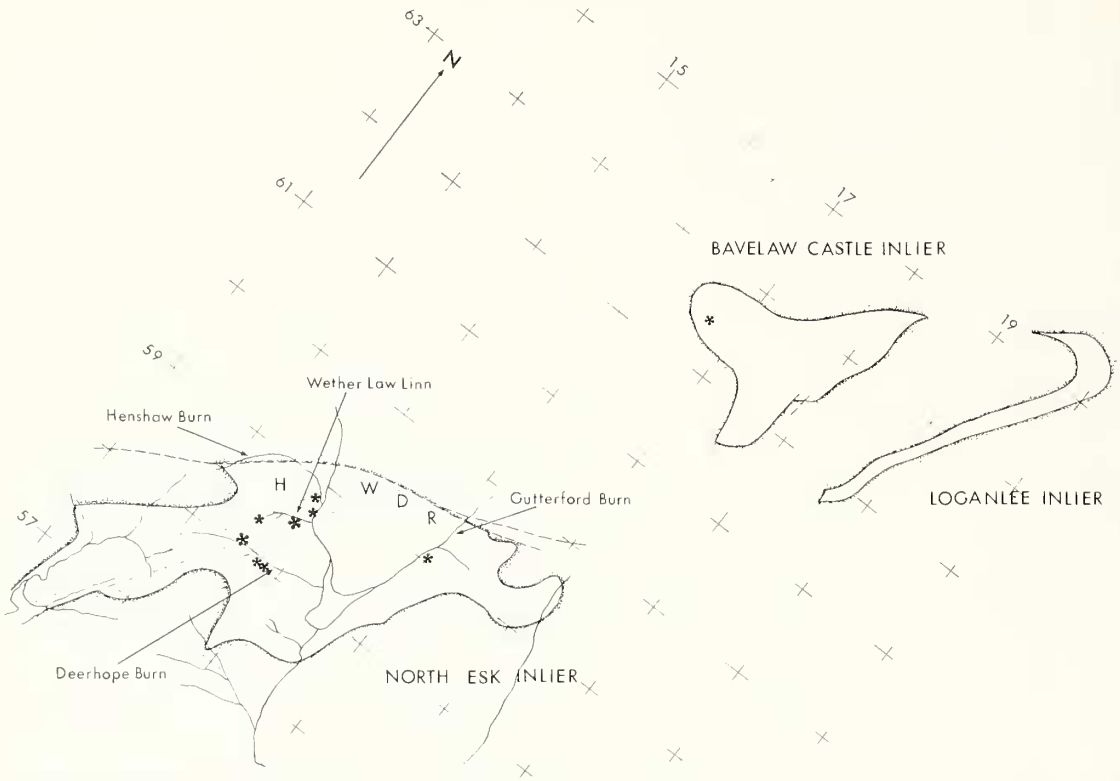

TEXT-FIG. 1. Sketch map showing the three Silurian inliers in the Pentland Hills relative to National Grid co-ordinates. Larger asterisks mark the most significant fossil localities, small asterisks show less important localities. R—Reservoir Formation; D—Deerhope Formation; W—Wether Law Linn Formation; H—Henshaw Formation. (Based on Tipper 1976.)

The overlying Deerhope Formation consists mainly of cross-bedded sandstones and conglomerates, but the upper part yields very abundant trilobites; *Podowrinella straitonensis* (Lamont) fragmentary *Encrinurus* specimens, and rare *Hemiarges rolfei* (Lamont), occuring along with the brachiopods *Isorthis* and *Glassia*.

Above this comes the highly fossiliferous Wether Law Linn Formation exposed at NT 145582 in the Deerhope Burn and NT 148586 in Wether Law Linn, of which faunal lists have been given by Tipper (1975, 1976). Whilst Tipper has documented a substantial change in the brachiopod faunas from unit A to unit C, marked by a white volcanic clay band, unit B, the trilobite fauna seems to have been relatively unaffected by this rapid pyroclastic deposition, so that in both units A and C there occurs *Proetus* (*Lacunoporaspis*) sp., *Cyphoproetus comitilis* n. sp., *Cyphoproetus depressus* (Barrande), *Calymene frontosa* (Lindström), *Encrinurus expansus* Haswell, *Youngia douglasi* Lamont, *Acernaspis* (*Eskaspis*) *sufferta* (Lamont), and *Anacaenapis dealgach* (Lamont).

A single large cheirurine hypostome was found by Tipper in unit C, in which very rare *Scotoharpes domina* Lamont also occurs, and a single unidentified odontopleurid pygidium was present at the junction of the upper Deerhope and Wether Law Linn Formations.

Unit D of the Wether Law Linn Formation is virtually unfossiliferous, though the holotype of *S. domina* came therefrom, but unit E, exposed in the Henshaw Burn yields *Encrinurus pagei* (Haswell), and from here also was collected a single *Scotoharpes* cephalon, and a fauna of brachiopods dominated by the Zygospirid *Pentlandella*.

A veteran student of trilobites from the Pentland Hills for more than thirty years has been Dr. A. Lamont, who in 1948 published a short paper with photographs of several trilobite species which were named but not described, and the validity of these names has in consequence been called into question. Whittington (1950) did not recognize *Scotoharpes* Lamont as a valid taxon, but Norford (1973) who had access to a plasticine replica of Lamont's material considered that it was, in fact, an available name. Likewise the specific name *sufferta*, for which *Acernaspis* (*Eskaspis*) was erected, was considered to be valid by Clarkson, Eldredge and Henry (1977). Recently Lamont (1978) published privately a more detailed work giving short descriptions of Pentland Hills trilobites, which were illustrated by sketches.

Dr. Lamont has kindly donated many of these specimens to the Royal Scottish Museum, so it has generally been possible to study these in detail. Lamont's nomenclature is accepted provided that Article 13a of ICZN is satisfied; such acceptance has been facilitated where the type specimens are well preserved and localized, and can be matched with equivalent material from the same horizons. The following species named by Lamont (1948, 1978) appear to come in this category: *Scotoharpes domina* (see Norford 1973; Clarkson *et al.* 1977); *Anacaenaspis dealgach* (*Bruxaspis dealgach* of Lamont 1978, syntypes available; *Leonaspis lothiana* (*Dudleyaspis lothiana* of Lamont 1948, 1978) holotype available; *Youngia douglasi*, holotype available; *Hemiarges rolfei*; (See Howells, in press). *Cyphoproetus glaudii* on the other hand is here considered *nomen nudum*. This species was figured in 1948 from two very poor specimens, a cranidium and a pygidium, but there was no accompanying description. In 1978 a hypostome and another cranidium were shown by sketches, but though there was a description the species cannot be identified from these alone and the specimens are now so abraded as to be unidentifiable. Hence the name *glaudii* should be suppressed. The other Pentland species figured (1948) or described and figured (1978) by Lamont, can be synonymized with established species (see following descriptions).

SYSTEMATIC DESCRIPTIONS

Family PROETIDAE Salter, 1864
Subfamily PROETINAE Salter, 1864
Genus PROETUS Steininger, 1831
Proetus (s.l.) cf. *latifrons* (McCoy, 1846)

Plate 77, fig. 6

1846 *Forbesia latifrons* McCoy, p. 49, fig. 11.
1973 *Proetus* (s.l.) *latifrons* (McCoy, 1846); Owens, p. 21, pl. 1, figs. 11, 12; pl. 2, figs. 1, 2, 4 (with synonymy).
1978 *Proetus* (s.l.) *latifrons* (McCoy, 1846); Thomas, p. 40, pl. 9, figs. 12, 13.

Figured Material. A single external mould of an incomplete specimen collected from the coral bed in the Upper Reservoir Formation at NT 147580, Deerhope Burn by S. D. G. Campbell, RSM GY 1978. 61. 524.

Dimensions. Cephalic length (sag.) 5 mm, width 5 mm, total preserved sagittal length of specimen (9 mm).

Remarks. The single specimen is incomplete, the front of the cephalon being broken, and only eight partial thoracic segments are still present. Nevertheless diagnostic features remaining include the broadly conical glabella, slightly wider than the axis of the occipital ring and the axis of the thorax, and the large occipital lobes.

Owens (1973) has shown that *P.* (s.l.) *latifrons* is probably confined to the Upper Llandovery of north-western Ireland, and the Wenlock Shale of the Mendip Hills, though some poorly preserved trilobites from Tortworth, May Hill, Shropshire, and Pembroke may also pertain to this species. If the specimen from the Reservoir Formation is truly *P.* (s.l.) *latifrons*, then the only point to be added to Owens's description is that the cranidium seems to be weakly granular.

Subgenus LACUNOPORASPIS Elkin, 1966
Proetus (*Lacunoporaspis*) sp.

Plate 77, figs. 4, 8–12

1948 *Proetus peeblesi*; Lamont, pl. 1, fig. 5.
1977 *Proetus latifrons* (McCoy); Clarkson *et al.*, pp. 120, 121 (list only).
1978 *Proetus* (*Forbesia*) *pitcairni* sp. nov. Lamont, p. 265, pl. xxx, figs. 1–4.
1978 *Proetus* (*Scotoproetus*) *fergali* subgen. et sp. nov. Lamont, p. 266, pl. xxx, fig. 5.
1978 *Proetus* (*Cornuproetus*) *dicuili* sp. nov. Lamont, p. 266, pl. xxx, figs. 8–10.
1978 *Praedechenella peeblesi* (Lamont, 1948); Lamont, p. 268, pl. xxx, fig. 13.

Figured material. Cranidia; RSM GY 1978. 61. 391, (Pl. 77, fig. 8): —399 (Pl. 77, fig. 9); —395, (Pl. 77, fig. 10); —393 (Pl. 77, fig. 11) (also figured Howells, in press); —394 (Pl. 77, fig. 12) and RSM GY 1979, 45. 3 (Pl. 77, fig. 4) (also figured Lamont? 1948, 1978 as *Praedechenella peeblesi*).

Other material. Cranidia; RSM GY 1978. 61. 384, —386, —90, —392.

Distribution. Cranidia of this species are quite common in units A and C of the Wether Law Linn Formation at NT 145582 and NT 148586, but they are often distorted or laterally compressed, giving rise to a rather wide variety of forms and hence to the range of separate 'species' described by Lamont. Thus the specimen upon which Lamont (1948) based the name '*Proetus peeblesi*' though unrecognizable from the photograph was described as having 'a remarkably long narrow conical central lobe' which might seem to validate the name under Article 13a of the Rules. Comparison with other specimens, however, shows that this morphology is quite atypical and is entirely due to lateral compression. The name '*peeblesi*' should be therefore suppressed as *nomen nudum*. Whilst some distorted librigenae and pygidia might belong to this species better material is awaited before figuring them.

Dimensions. Cranidia range in size from 4·0 to 5·5 mm in length, and have a glabellar width across the base 3·5 to 4·5 mm.

Description. Cranidium about as wide as long. Glabella tapering forwards to bluntly rounded point, as long as wide across base, slight constriction opposite 2S, moderately inflated, normally reaching anterior border. 1S abaxial branch opposite midpoint of palpebral lobe transverse, adaxial branch running backwards at about 50° to exsagittal line dying out before reaching occipital furrow. Small shallow depression continuing line of abaxial branch. 2S opposite anterior limit of palpebral lobe, shallower than 1S, backwardly directed, about one-third way from 2S to anterior end of glabella. Anterior border not greatly inflated, one-eighth length (sag.) of cranidium. Occipital furrow deep, median part transverse, laterally curving anteriorly. Occipital ring as wide as glabella, one-seventh length (sag.) of cranidium, with median tubercle. Occipital lobes small, ovate, depressed below level of glabella. Anterior branch of facial suture diverging at about 10° to exsagittal line from anterior limit of palpebral lobe, curving adaxially as crosses anterior border. Posterior facial suture diverging slightly and

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EXPLANATION OF PLATE 77

Figs. 1, 2. *Scotoharpes domina* Lamont. Wether Law Linn Formation, unit E, Henshaw Burn. North Esk Inlier. 1. Latex replica of external mould, RSM GY 1978. 61. 504b, ×3. 2. Lower lamella of fringe, RSM GY 1978. 61. 504a, ×6·5.

Figs. 3, 5, 7. *Cyphoproetus comitilis* n. sp. Wether Law Linn Formation, unit A, Deerhope Burn; paratypes. 3. Incomplete specimen, internal mould. RSM GY 1978. 61. 419, ×8. 5. Latex replica of thoracopygon, RSM GY 1978. 61. 411, ×6. 7. Librigena, internal mould, RSM GY 1978. 61. 416, ×6·5.

Figs. 4, 8–12. *Proetus* (*Lacunoporaspis*) sp. Wether Law Linn Formation, units A and C, Deerhope Burn and Wether Law Linn; cranidia. 4. RSM GY 1979. 45. 3, figured by Lamont 1978 as *Praedechenella peeblesi*, ×5·25. 8. Internal mould, RSM GY 1978. 61. 391, ×6. 9. RSM GY 1978. 61. 399, ×6. 10. RSM GY 1978. 61. 395, ×6. 11. RSM GY 1978. 61. 393 (also figured Howells, in press), ×6. 12. RSM GY 1978. 61. 394, ×6 (9–12; latex replicas of external moulds).

Fig. 6. *Proetus* (s.l.) cf. *latifrons* (McCoy), Coral bed in Reservoir Formation, Deerhope Burn. Incomplete specimen, latex replica of external mould, RSM GY 1978. 61. 524, ×6.

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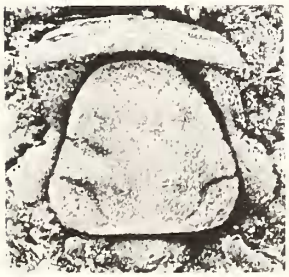

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CLARKSON and HOWELLS, Silurian trilobites

then more sharply posteriorly, but crossing posterior borders a short distance from the glabella (above the width of the occipital lobes). Palpebral lobe about one-third sagittal length of cranidium. Surface sculpture of cranidium nearly smooth, with slight granularity.

Discussion. The cranidia from the Pentland Hills resemble those of *P.* (*L.*) *confossus* Owens, 1973 in form, but the glabellar furrows are more deeply impressed and the glabella is less inflated. the palpebral lobe is appreciably longer and is set further back than that of *P.* (*L.*) *confossus*, resembling more that of *P.* (*L.*) *oppidanus* Thomas, 1978. The latter, however, has a longer and narrower glabella, as has *P.* (*L.*) *obconicus* (Lindström, 1885) and 1S and 2S in these species do not connect with the axial furrow. Librigenae occurring in the same beds which may belong to this species are poorly preserved but do not seem to have the characteristic pitting of *P.* (*L.*) *confossus* and *P.* (*L.*) *obconicus* and in view of this and their longer genal spines are closer to those of *P.* (*L.*) *oppidanus*.

The species does not closely resemble *P.* (s.l.) *latifrons* (McCoy, 1846) as described by Owens (1973), since in the latter the base of the glabella is relatively wider and the glabellar furrows not at all impressed.

In the absence of good librigenae and pygidia no further determinations can yet be made. The specific name *pitcairni* may be available for this species but since the material gathered to date consists of isolated fragments only, we feel for the moment that it is wisest to leave this under open nomenclature until more complete specimens come to hand.

Genus CYPHOPROETUS Kegel, 1927

Cyphoproetus comitilis n. sp.

Plate 77, figs. 3, 5, 7; Plate 78, figs. 1, 2, 4, 5, 7, 9–11.

?1948 *Cyphoproetus glaudii* Lamont, pl. 1, figs. 3–4.
1977 *Cyphoproetus depressus* (Barrande,1846); Clarkson *et al.*, pp. 120, 121 (list only).
?1978 *Cyphoproetus* (*Carlopsia*) *glaudii* Lamont; Lamont, p. 267, pl. xxx, figs. 6, 7.
?1978 *Cyphoproetus* cf. *puncticillosus* (Lindström); Lamont, p. 267, pl. xxx, fig. 12.

Type material. Holotype; RSM GY 1978. 61. 400a, b (complete specimen, part and counterpart) (Pl. 78, figs. 1, 2, 4, 11). Paratypes; (complete or partial specimens) RSM GY 1978. 61. 401 (Pl. 78, fig. 5); —404 (Pl. 78, fig. 9); —411 (Pl. 77, fig. 5); —413 (Pl. 78, fig. 7); —419 (Pl. 77, fig. 3); —416 (Pl. 77, fig. 7).

Other material. About thirty other specimens in the Royal Scottish Museum collections, including RSM GY 1978. 61. 406, —410, —412, —414, and —415.

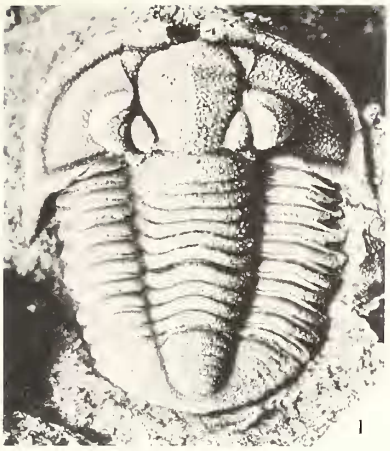
Etymology. comitilis (Latin) means 'small companion', since the species occurs in association with the larger, closely related *C. depressus* at the same horizon.

Distribution. This species occurs not infrequently in units A and C of the lower Wether Law Linn Formation both at NT 145582 and NT 148586. It is especially common just below the white clay band, (unit B of Tipper, 1975, 1976). It seems to be confined to this horizon in the Telychian.

EXPLANATION OF PLATE 78

Figs. 1, 2, 4, 5, 7–9, 11. *Cyphoproetus comitilis* n. sp. Wether Law Linn Formation, units A and C. Deerhope Burn (1, 2, 4, 5, 11) and Wether Law Linn (7–9). 1, 2, 4, 11. Holotype, RSM GY 1978. 61. 400a. 1, 2. Latex replica of external mould of intaglio, ×6. 4. Internal mould of holotype, RSM GY 1978. 61. 400b, ×6. 11. Enlargement of glabella showing surface sculpture, ×14. 5. external mould of partial specimen RSM GY 1978. 61. 401*, ×6. 7. Latex replica; external mould of enrolled specimen, RSM GY 1978. 61. 413*, ×7. 9. Internal mould of almost complete specimen, RSM GY 1978. 61. 404*, ×6. * paratypes.

Figs. 3, 6, 8, 10. *Cyphoproetus* cf. *depressus* Lindström. Wether Law Linn Formation, units A and C, Deerhope Burn (6, 8, 10) and Wether Law Linn (3). 3. Almost complete specimen, latex replica external mould, RSM 1978. 61. 404, ×3·5. 6. Partial, crushed specimen, latex replica of external mould, RSM 1978. 61. 403, ×3·75. 8. Damaged cranidium, internal mould, RSM GY 1978. 61. 417, ×5. 10. Cranidium internal mould; RSM GY 1979. 45. 4, figured by Lamont (1978, pl. xxx, fig. 6) as *Cyphoproetus* (*Carlopsia*) *glaudii*, ×5.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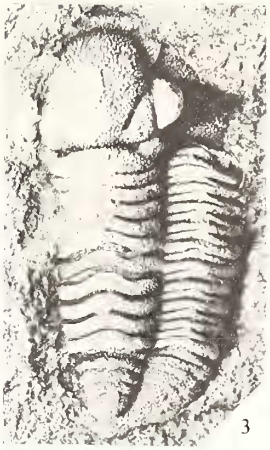
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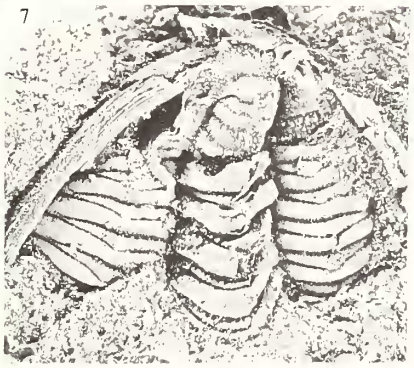
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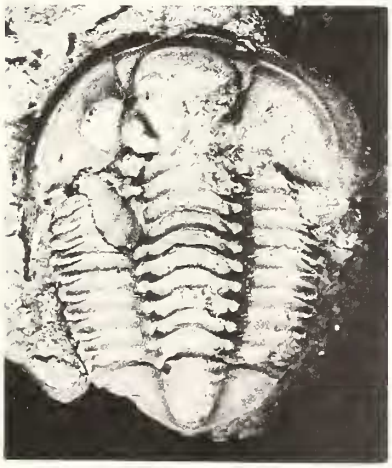
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CLARKSON and HOWELLS, *Cyphoproetus*

Diagnosis. Small *Cyphoproetus* with deep 1S, 2S, and 3S clearly defined, 4S very shallow, anterior border not sagitally widened, lacking pre-glabellar field sagittally, lateral cephalic margin incurved at base of genal spine, a faintly defined glabellar lobe adaxial to 1S and opposite 1L is visible on internal moulds.

Dimensions. Holotype. Total length 8·5 mm, width 8·0 mm, cephalic length (sag.) 2·6 mm. Range in total length 8–11 mm.

Description. Cephalon moderately convex, virtually twice as wide (tr.) as long (sag.), one-third length of dorsal shield. Glabella only very slightly longer (sag.) than wide (tr.), weakly inflated, straight-edged anteriorly. 1S deep and wide at its midlength shallowing more rapidly posteriorly and merging into occipital furrow, remaining relatively deep anteriorly until just before axial furrow where it shallows rapidly, aligned at 20° to exsagittal line, running backwards from opposite anterior limit of palpebral lobe and defining 1L. 1L ovate, two-fifths exsagittal length of glabella, one-sixth its basal width (tr.), rounded posteriorly, slightly pointed in outline anteriorly. 2S transverse, shallowing adaxially, just anterior to anterior limit of palpebral lobe. 3S transverse or running forwards slightly, just a little shorter (tr.) than 2S. ?4S very shallow transverse depression seen only on internal mould midway between 3S and anterior limit of glabella. In some specimens and particularly on internal moulds, a faintly defined rounded lobe about half the length of 1L appears to lie adaxial to 1S (see Pl. 78, figs. 2, 9). Occipital furrow narrow (sag.), well-defined, deepening a little where it curves laterally and posteriorly around posterior limit of 1L. Occipital ring one-sixth length (sag.) of cranidium, as wide (tr.) as anterior border, five times wider than long. Median tubercle anteriorly placed. Occipital lobe small, ovate, about three-quarters length (exsag.) of occipital ring.

Anterior border, convex, one-eighth length (sag.) of cranidium. Anterior border furrow of cranidium deep and well-defined. Preglabellar field absent sagittally but present laterally as subtriangular area, convex, but depressed below level of glabella and anterior border. Anterior branch of facial suture diverging abaxially forwards at 20° from opposite 2S, curving adaxially forwards from anterior border furrow. Posterior branch of facial suture initially almost transverse then running at 70° to the exsagittal line, cutting the posterior border midway along its length. Palpebral lobe subparabolic, abutting against 1L. Visual surface of eye strongly curved in plan and profile and with many tiny lenses and shallow subocular furrow.

Field of librigena moderately convex. Lateral border widens a little posteriorly but incurved at base of genal spine. Lateral border furrow shallower than anterior border of cranidium. Posterior border furrow deeper and narrower than lateral border furrow. Posterior border slightly narrower than lateral border, merging with lateral border to produce short genal spine without median furrow and which extends at least as far as fourth thoracic segment. All raised surfaces very finely granulated. Cephalic doublure with terrace ridges, reaching at least as far as limit of raised border.

Thorax of ten segments. Axis one-third width (tr.) of thorax narrowing posteriorly to three-quarters anterior width. Axial ring short (sag.) eight times wider than long. Adaxial part of pleuron horizontal and transverse recurving ventrally beyond fulcrum. Pleuron terminating laterally as blunt point.

Pygidium approximately twice as wide as long. Axis about one-third total pygidial width anteriorly, tapering backwards to blunt point, with very weak postaxial ridge present on internal moulds. Five axial rings delimited by shallow axial ring furrows. Pleural areas with four pairs of ribs which curve gently backwards abaxially. Pleural and interpleural furrows shallow and both extending close to margin. Thoracic axis and pygidium have smaller and less dense granules than those of cephalon.

Discussion. From Owens (1973, p. 28, Table 5) the non-sagittally widening anterior border of the Pentland Hills species is also found in *C. facetus* Tripp, 1954, *C. rotundatus* (Begg, 1939), both Ordovician, and *C. externus* (Reed, 1935), Llandovery. However, *C. comitilis* can be distinguished from *C. externus* which possesses a minute preglabellar field, and from the two Ordovician species in that the lateral cephalic margin incurves at the base of genal spine. The other Silurian forms *C. depressus* (Barrande, 1846), *C. binodosus* (Whittard, 1938), *C. strabismus* (Owens, 1973), and a new species from the Llandovery of Girvan are distinct from the Pentland form in possessing a sagittally widened anterior border. The specimens upon which Lamont based the name *C. glaudii*, though available, are now so badly abraded that it is not possible to tell from these whether the species represented is *C.* cf. *depressus* or *C. comitilis*. Likewise the drawings in Lamont's 1978 work and his photograph (1948, pl. 1, fig. 3) are of distorted and poorly preserved specimens which cannot be assigned to either species.

Cyphoproetus cf. *depressus* (Barrande, 1846)

Plate 78, figs. 3, 6, 8, 10

1846 *Cyphaspis depressus* Barrande, p. 60.
1946 *Cyphoproetus depressus* (Barrande), Přibyl, p. 36, pl. 1, figs. 9, 9*a*.
1948 ?*Cyphoproetus glaudii* Lamont, pl. 1, figs. 3, 4.
1978 ?*Cyphoproetus* (*Carlopsia*) *glaudii* subgen. et sp. nov. Lamont, p. 267, pl. xxx, figs. 3, 4.

Material and remarks. Specimens include RSM GY 1978. 61. 403 (Pl. 78, fig. 6); —405 (Pl. 78, fig. 3) —417 (internal moulds of cephala); —402 (a partially decalcified external mould, not figured); and 1979. 45. 4 (Pl. 78, fig. 10 figured by Lamont, 1978 as *C. glaudii*). This species is appreciably larger than *C. comitilis* though well within the size range of *C. depressus*, quoted by Owens for the species, the sagittal lengths of the cranidia for specimens —403, —405, and —407 being 6·5, 5·75, and 6·0 mm respectively. The sagittal flattening and widening of the anterior border is most clearly seen in 1979. 45. 4, though in neither of the large complete specimens are the genal spines preserved. In all other respects, e.g. the shape and dimensions of the 1L lobes, the form of the glabella, and the granulation of the exoskeleton, the specimens approximate *C. depressus*. 1S in 1978. 61. 405, very deeply incised medially, is very like that of specimens from Dolyhir figured by Thomas (1978, pl. 11, figs. 1, 2). All specimens come from unit A of the Wether Law Linn Formation at NT 145582, just below the white clay band, unit B.

Family AULACOPLEURIDAE Angelin, 1854
Genus HARPIDELLA McCoy, 1846

Remarks. Thomas and Owens (1978) have discussed the taxonomic status of the genus and Thomas (1978) has listed the known species.

Harpidella (*Harpidella*) *thomasi* n. sp.

Plate 79, figs. 1, 2, 16

Holotype. The holotype and only known specimen (part and counterpart, GSE 13519 —20), 6·5 mm broad to tips of genal spines, was collected by W. MacConochie on the south bank of the Deerhope Burn and comes from the uppermost beds of the Reservoir Formation at NT 148580. An isolated pygidium 3·5 mm broad (GSE 13517) may possibly belong to this species.

Etymology. After Dr. A. T. Thomas, in respect of his work on Aulacopleuridae.

Diagnosis. A *Harpidella* (*Harpidella*) species with anterior border of uniform length sagittally and exsagittally, smooth exoskeleton, glabella half total length (sag.) of cephalon and stout recurved genal spine.

Description. Cephalon semicircular to subtrapezoidal, border most strongly curved where cut by anterior branch of facial suture and twice as wide (tr.) as it is long (sag.) (to base of genal spine). Cranidial length more than three-quarters its width. Occipital ring convex nearly as wide (tr.) as distance from occipital furrow to anterior border furrow, with a low occipital granule. Occipital furrow deep and narrow. Glabella flush with general convexity of cephalon, about half length of cranidium three-quarters as long (sag.) as greatest width at the lobes, anterior outline a slightly flattened semicircle. Axial furrow narrow, continuous, and deeply incised, except directly opposite 1L. 1S very deep, arising from axial furrow half-way along glabella and isolating relatively large 1L, which is elliptical sagittally, half the length of glabella and a quarter of its total width, hardly delimited from fixigena by axial furrow. 2S barely perceptible, approximately a quarter the distance from front of glabella. Occipital, axial, the pre-glabellar furrows, and 1S all about same width and depth, axial furrow shallow opposite 1L. Preglabellar field two-thirds length of glabella, a little inflated, and slightly peaked anteriorly, descending to broad and deep anterior border furrow. Anterior border forming strong ridge of constant width as far as base of genal spine, half that (tr.) of preglabellar field. Anterior section of facial suture diverging outwards at about 30° from exsagittal plane, curving in again as it crosses anterior border. Palpebral lobe semicircular, remote from axial furrow, anterior edge of eye directly opposite preglabellar furrow, posterior edge opposite centre of 1L; nearly as long as glabella. No indication of ocular ridge. Posterior branch of facial suture at about 80° to exsagittal line, nearly straight, terminating nearly at base of genal spine.

Librigena relatively narrow (tr.) with strong convex border and wide and deep lateral border furrow; posterior border furrow shallower, posterior border narrow. Visual surface of eye large and semicircular, extending

laterally to within short distance of lateral border. Librigenal field thus long (sag.) and narrow (tr.), inclined at about 45° and almost flat. Genal spine broader (tr.) at its base than lateral border with which it is continuous, about as long (sag.) as cephalon, curving away from the cephalon and turning in again in a continuous curve at about half-way along its length, tapering posteriorly. Concentric terrace ridges on both upper and lower surface of genal spine parallel with length of spine. Cephalic doublure narrow with concentric terrace ridges, rostral plate unclear. No other surface sculpture present.

Thorax of holotype probably incomplete, ten segments are known; axis convex, one-third the total width of thorax, broadest at second and third thoracic segment where it is slightly broader than glabella, but slightly tapering posteriorly. Axial spine present on sixth segment but incompletely preserved. Each axial ring narrowing slightly laterally and turning forwards to join with flat pleuron at distinct axial furrow. Pleura with narrow transverse furrow, more clearly defined posteriorly and possessing distinct pleural facets on first few segments.

The poorly preserved single isolated pygidium (GSE 13517) is subtriangular, nearly twice as broad (tr.) as long (sag.), axis convex, one-third of the pygidial width anteriorly and with four or five axial rings. Pleural field with only faint traces of segmentation, border absent.

Discussion. H. (*H.*) *thomasi* is probably closest to *H.* (*H.*) *aitholix* Thomas from the Wenlock Coalbrookdale formation (Thomas 1978, p. 32, l. 8), but in the latter the anterior border is widened sagittally, the glabella is relatively larger, and fairly large tubercles are rarely present on the glabella and preglabellar field. It is also distinct from *H.* (*H.*) *helenae* Lane 1979, which likewise has a distinct tubercular sculpture and a larger glabella also a broader and more pointed anterior border.

Family HARPETIDAE Hawle and Corda, 1847
Genus SCOTOHARPES Lamont, 1948
Scotoharpes domina Lamont, 1948

(Plate 77, figs. 1, 2)

1948*a* *Scotoharpes domina* Lamont, p. 532, fig. 2, p. 534.
1948*b* *Scotoharpes domina* Lamont; Lamont, pp. 376–377, fig. 2.
1973 *Scotoharpes domina* Lamont; Norford, p. 14, pl. 1, figs. 1–3.

Remarks. Norford (1973) has already accepted the validity of the genus and has given a full description based upon the unnumbered holotype, of which a plasticine replica was furnished by Dr. Lamont. This came from the lower part of unit D of the Wether Law Linn Formation at

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EXPLANATION OF PLATE 79

Figs. 1, 2, 16. *Harpidella* (*Harpidella*) *thomasi* n. sp. upper Reservoir Formation, Deerhope Burn 1, 2. GSE 13519–20, holotype. 1. Latex replica of external mould, ×9. 2. Internal mould of same. 16. Pygidium, latex replica of external mould, GSE 13517, ×5.

Figs. 3–11. *Calymene frontosa* Lindström. Wether Law Linn Formation, Deerhope Burn and Wether Law Linn. 3. Internal mould of cranidium (figured by Lamont 1949 as holotype of *Calymene carlops*), Gr. I. 1518, ×5·5. 4. Internal mould of small pygidium, RSM GY 1978. 61. 541, ×3·5. 5. Smallest known pygidium, latex replica of external mould, RSM GY 1978. 61. 540b, ×4·5. 6. Complete specimen, latex replica of external mould, GSE 1013, ×6·75. 7. Same, internal mould, GSE 1014, ×6·75. 8. Cranidium, internal mould, RSM GY 1978. 61. 539, ×4·25. 9. Pygidium, internal mould, RSM GY 1978. 61. 545, ×4·25. 10. Pygidium, latex replica of external mould, RSM GY 1978. 61. 544, ×4·75. 11. Cranidium, latex replica of external mould, RSM GY 1978. 61. 537, ×3·25.

Fig. 12. *Acernaspis* (*Eskaspis*) *sufferta* (Lamont). Hypostome, slightly distorted anteriorly, internal mould. Wether Law Linn Formation, unit C, Deerhope Burn, RSM GY 1978. 61. 510a, ×10.

Figs. 13–15. *Hemiarges rolfei* Lamont. Upper Deerhope Formation, Deerhope Burn. 13. Cranidium, internal mould, RSM GY 1979. 45. 2 (figured by Lamont as holotype of *H. hendersoni*), ×5·5. 14. Partial pygidium, latex replica of external mould, RSM GY 1978. 61. 511b, ×4. 15. hypostome, internal mould, Gr. I. 40306, ×5.


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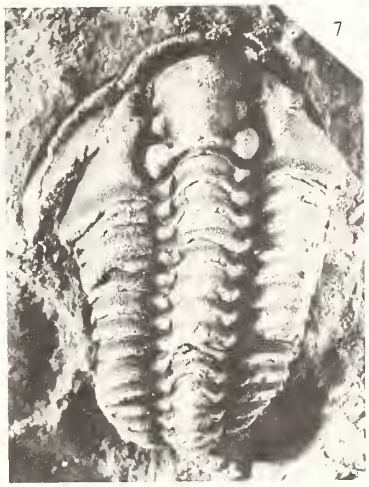
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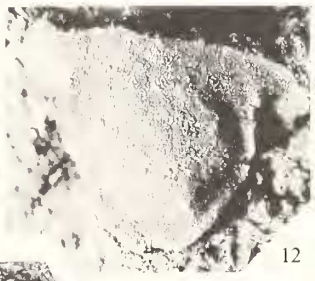
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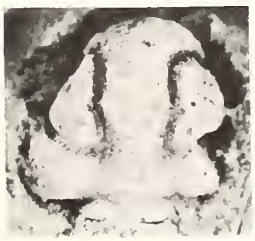
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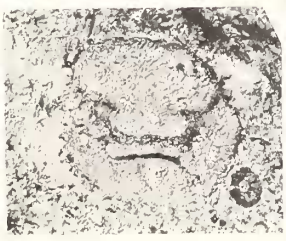
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CLARKSON and HOWELLS, Silurian trilobites

NT 149587 in the Henshaw Burn. Three other specimens are known of which one is here figured, RSM GY 1978. 61. 504a, b; an almost complete cephalon 18 mm long, including the brim; the dorsal and part of the ventral lamella of the brim preserved, from unit E of the Wether Law Linn Formation. The specimen was collected in 1971 by Mr. Hugh Mackenzie. The other specimens are RSM GY 1978. 61. 547, a partial fringe from unit C, and RSM GY 1965. 18. 3 from unit E at NT 144585 collected by R. W. Lamond.

Some additional details of morphology can be added to Norford's description from RSM GY 1978. 61. 504a, b. The eye-tubercles are very prominent and are connected to the glabella by slender ocular ridges, the apparent lack of sculpture of the glabella and adjacent regions mentioned by Norford is confirmed, though extremely faint continuations of the radial ridges of the fringe extend some distance up the cheek roll, though do not cover the genal surface as in *S. loma* (Lane). The structure of the fringe, and especially the lower lamella is more clearly displayed in this specimen than in the holotype. The rim is substantially raised above the fringe and has a flat surface indented by a narrow concentric groove from which the inner face of the rim shelves to a single row of pits at the junction of rim and fringe. A less well-defined second row of pits lies immediately within the first row; interior to this the pattern of fringe pits is less regular, though towards the inner margin the pits become orientated between the smooth radial ridges which are more pronounced near the girder but fade out midway across the fringe towards its outer edge. These ridges are most prominent at the antero-lateral corners of the cephalon and seem to be more pronounced on the ventral lamella. The girder forms a narrow curving ridge sculptured with a single row of tiny granules.

Family CHEIRURIDAE Hawle and Corda, 1847
Subfamily CHEIRURINAE Hawle and Corda, 1847
Cheirurinae indet.

Plate 80, fig. 3

Material. A single large cheirurid hypostome, RSM GY 1978. 61. 533, 18 mm long (sag.) and 20 mm wide (tr.), excellently preserved as an internal and external mould, was found in Unit C of the Wether Law Linn Formation at NT 148586 by J. C. Tipper.

Description. Hypostome slightly longer (sag.) than wide (tr.) including wings. Anterior border semicircular. Central body large and convex, very nearly reaching anterior border, and with its frontal margin more strongly curved than the latter, being separated from it by a deep and narrow furrow, broadening laterally. Posteriorly the central body narrows to a distinct waist at the middle furrows and then broadens slightly to terminate in a posterior lobe about a fifth the length of the central body and with a semicircular posterior margin. Middle furrows deeply cut, inclined backwards at 50–60° to the exsagittal plane. Anterior section of lateral border rather swollen indenting central body, postero-lateral border of constant width behind middle furrow, sharply angled to meet transverse posterior border. Surface of hypostome densely granulate, granules more pronounced on the postero-lateral border.

Remarks. No other evidence of large cheirurines in the Pentland Hills has been forthcoming other than this single hypostome. Since cheirurine hypostomes are all rather similar it is hard to know which, if any, of the known Llandoverian cheirurine genera it might pertain. *Cheirurus*, *Ktenoura*, *Hadromeros*, and *Proromma* all occur at this horizon (Lane 1971) but this specimen cannot be matched exactly with any of those previously figured.

Subfamily ACANTHOPARYPHINAE Whittington and Evitt, 1954
Genus YOUNGIA Lindström, 1885
Youngia douglasi Lamont, 1948

Plate 80, figs. 1, 2, 5, 6, 11

1948 *Cheirurus* (*Youngia*) *douglasii* Lamont, pl. 1, fig. 12.
1978 *Youngia douglasii* Lamont; Lamont, p. 274, pl. xxx, figs. 14, 15.

Type material. Holotype: RSM GY 1979. 77. 38 cranidium, internal mould figured by Lamont (1948, 1978) is well preserved (Pl. 80, fig. 11) but the librigena (1978, fig. 15) is barely recognizable and is not figured again here.

Other figured material. Four cranidia: RSM GY 1978. 61. 505 (Pl. 80, fig. 1); —507a (Pl. 80, fig. 5); —508 (Pl. 80, fig. 6); —516 (Pl. 80, fig. 2).

Other material. Cranidia: RSM GY 1978. 61. 507b; —525; —526.

Distribution. This species occurs in units A and C of the Wether Law Linn Formation at NT 148586 and NT 145582.

Diagnosis. A species of *Youngia* lacking a large occipital spine but with a small spine on the lateral border below the genal spine.

Dimensions. The size range of the known cranidia is considerable. The smallest cranidium is that of the holotype with a length of 4·5 mm, whilst the largest cranidium (—507a) is 11 mm long and if complete would be 20 mm broad.

Description. Glabella inflated, widest across 1L, wider than long. 1L two-fifths width (tr.) of glabella, not delimited adaxially. 2L and 3L progressively narrower (tr.) than 1L and slightly shorter. 1S deep and well-defined, abaxially obliquely aligned, adaxially curving towards but not reaching occipital furrow. 2S and 3S not so deeply impressed as, and parallel to, abaxial part of 1S, reaching not so far across the glabella. Occipital furrow as wide and as deep as 1S. Occipital ring narrower (tr.) than glabella, five times wider than long, longer sagittally than medially to accommodate 1L. No occipital spine preserved and seemingly absent. Axial furrow deep and well-defined.

Fixigena, excluding spines, subrectangular in outline. Posterior border short (exsag.) adaxially, expanding laterally into long genal spine at least half length of glabella. Posterior border furrow wide and deep. Lateral border wide with very small spine just below posterior branch of facial suture. Eye not preserved. Anterior branch of facial suture parallel to axial furrow, posterior branch transverse turning posteriorly as it crosses lateral border. Surface of cranidium covered with coarse, irregularly sized granules. These are almost in contact with each other on the glabella, but smaller and most distantly spaced on the fixigena and occipital ring, becoming fewer and less distinct towards the tip of the genal spine.

Discussion. Y. douglasi differs from the type species *Y. trispinosa* in the absence of an occipital spine and that 1L is not circumscribed; it also has a lateral border spines on the fixigena. *Youngia* sp. 1 and 2 described by Perry and Chatterton (1977) also has 1L circumscribed. Of these, sp. 1 has a long occipital spine whilst sp. 2 has only a 'short spinose tubercle'. *Y. copelandi* (Perry and Chatterton, 1979) has a short occipital spine, two short spines on the lateral border below the genal spine, and has much larger granules whilst 1L is circumscribed. The closest resemblances seem to be with Lindström's (1885) species *Y. inermis* and *Y. globiceps* from Gotland in which the occipital spine is reduced or absent. These two species, however, are poorly known.

Family ENCRINURIDAE Angelin, 1854
Subfamily ENCRINURINAE Angelin, 1854
Genus ENCRINURUS Emmrich, 1844
Encrinurus expansus Haswell, 1865

Plate 80, figs. 4, 7–9, 10, 12

1865 *Encrinurus expansa* (sic.) Haswell, p. 36, pl. IV, figs. 4, 5.
?1948 *Encrinurus pluc* Lamont, pl. 1, fig. 14 (no description; poor illustration).
?1948 *Encrinurus calgach* Lamont, p. 6, pl. 1, figs. 15, 16 (no description; poor illustration).
1975 *Encrinurus calgach* Lamont; Clarkson, pp. 12, 23, figs. 2D–F (illustration of eye).
1978 *Calgachia calgach* Lamont; Lamont, p. 270, pl. XXXI, fig. 5. (*nomen nudum*).

Figured material. Haswell's types being lost, the description is based on other material; intaglio of length 2·2 mm collected by Dr. J. L. Henry, RSM GY 1978. 61. 427a, b (Pl. 80, fig. 12); partly enrolled external mould, RSM GY 1978. 61. 420 (Pl. 80, fig. 7); external mould of ventral surface with hypostome, —421 (Pl. 80, fig. 8); internal mould of librigena with eye, —448 (Pl. 80, fig. 9); external mould of small intaglio lacking librigenae, —438 (Pl. 80, fig. 4); internal mould of cranidium, —453 (Pl. 80, fig. 10).

Distribution. All material comes from the Wether Law Linn Formation (units A and C) at NT 145582 and NT 148586.

Dimensions. The largest intaglio is 25 mm long and has a cephalon 8 mm long by 15 mm broad; the smallest cephalon is 6 × 12 mm, the largest 9 × 22 mm.

Diagnosis. 1L reduced to very small ridge. Lateral glabellar lobes larger than tubercles on glabellar lobe. General tubercle formula: II—1⁂; iii—0; III—1. Anterior border with single row of ten tubercles. Short genal spine. Lateral part of field of fixigena with very few tubercles but many pits. Lateral border of librigena with one row of tubercles; field of librigena with five or six faintly raised tubercles and with shallow pits; precranidial lobe with two or three rows of tubercles. Pygidium with seven pleural ribs (eighth pair fused behind axis); fifteen to twenty axial rings; terminating posteriorly in upturned mucro.

Description. Cephalon a little over twice as wide (tr.) as long (sag.) width taken at posterior border. Glabella approximately twice as long as width across 2L lobes, expanding anteriorly to twice width across 2L lobes. Occipital ring five times wider than long. Occipital apodeme short and circular in outline. Occipital furrow combined with 1S medially producing broad furrow between occipital ring and 2L. 1L present only laterally as very small, ridge-like swelling between occipital apodeme and 1S apodeme. 2L, 3L, and large tubercle overhanging axial furrow anterior to these much larger than glabellar tubercles and roughly circular in outline. 1S apodeme, circular in outline, long and larger than occipital apodeme. 2S apodeme, as 1S apodeme; 2S furrow distinguishable only between 2L and 3L. 3S apodeme, circular in outline, shorter and smaller than 2S apodeme; 3S furrow present only between 3L and large overhanging tubercle. Preglabellar furrow broad, more deeply impressed laterally, terminating by very deep and wide anterior pit. Tubercle formula: II—1⁂; iii—0; III—1; III—2⁂ sometimes present. Anterior border of cranidium with single row of ten tubercles with lateral tubercle as large as 3L. Occipital ring and all furrows lack sculpture. Remainder of glabella with irregularly placed tubercles. Fixigena subtriangular in outline, wide and narrow laterally. Posterior border short (exsag.) adaxially, lengthening abaxially and projected into short genal spine. Posterior border furrow broad and shallow. Lateral border present only close to genal angle, where narrow, merging with posterior border. Anterior section of facial suture running diagonally forwards from eye crossing axial furrow at anterior pit and defining outline of anterior border of cranidium. Posterior section of facial suture crossing lateral border opposite occipital apodeme. Four tubercles overhanging axial furrow alternating in position with lateral glabellar lobes. Remainder of convex part of cheek with few large tubercles and pits increasing in number laterally. Borders and furrows without sculpture.

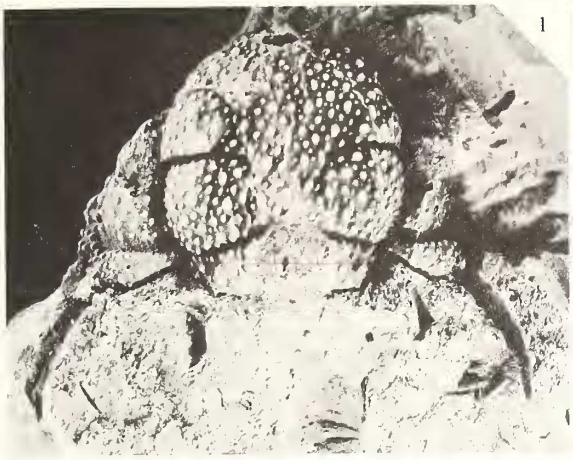
Pedunculate eye with wide base equalling width of two tubercles overhanging axial furrow; about as wide as high; visual surface tapering to blunt point dorsally. Librigena very gently convex, over twice as long as wide, width taken at position of eye. Lateral border of librigena wide (tr.) a quarter width of librigena at eye position narrowing rapidly and merging with very narrow anterior border of cephalon. Single row of large tubercles on lateral border increasing in size and definition anteriorly. Anterior border with few low tubercles. Lateral border

EXPLANATION OF PLATE 80

Figs. 1, 2, 5, 6, 11. *Youngia douglasi* Lamont. Wether Law Linn Formation, units A and C. Deerhope Burn. 1. Cranidium with spines, internal mould, RSM GY 1978. 61. 505, ×5·25. 2. Partial cranidium in dorso-lateral view, latex replica of external mould, RSM GY 1978. 61. 516, ×4·5. 5. Almost complete cranidium, latex replica of external mould, RSM GY 1978. 61. 507a, ×3·5. 6. Glabella, internal mould, RSM GY 1978. 61. 508, ×3·75. 11. Holotype; glabella, internal mould. RSM GY 1979. 77. 38a, ×5·5.

Fig. 3. Cheirurinid hypostome, latex replica of external mould, RSM GY 1978. 61. 533, ×2.

Figs. 4, 7–10, 12. *Encrinurus expansus* Haswell. Wether Law Linn Formation, units A and C. Deerhope Burn (8, 12) and Wether Law Linn Formation (4, 7, 9, 10). 4. Small intaglio devoid of librigenae; latex replica of external mould, RSM GY 1978. 61. 438, ×4. Partly enrolled external mould, latex replica, RSM GY 1978. 61. 420, ×4. 8. Latex replica of cephalic doublure and hypostome, RSM GY 1978. 61. 421, ×3·5. 9. Internal mould of left librigena with eye, RSM GY 1978. 61. 448, ×3·75. 10. Internal mould of cranidium, RSM GY 1978. 61. 453, ×2·5. 12. Intaglio devoid of librigenae, latex replica of external mould, RSM GY 1978. 61. 427a, ×3.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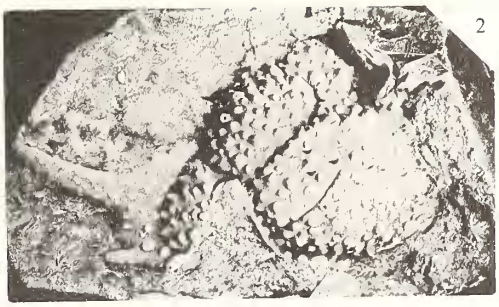
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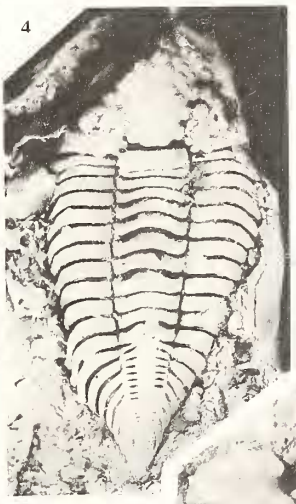
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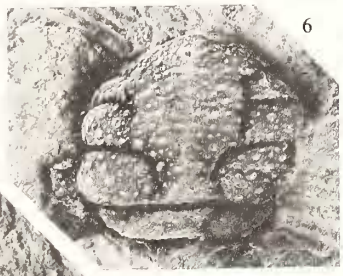
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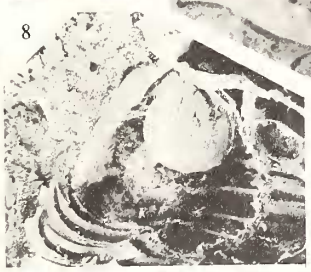
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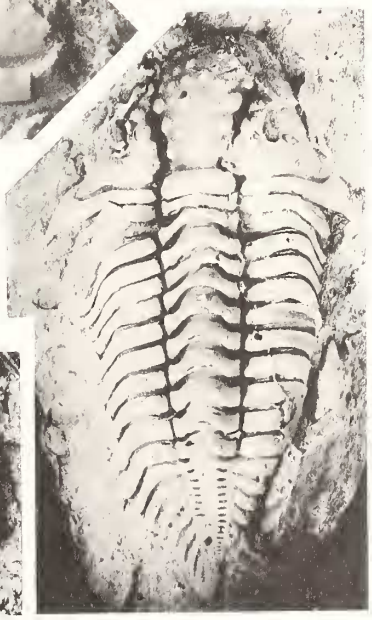


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CLARKSON and HOWELLS, Silurian trilobites

furrow well-defined, deepening anteriorly. Anterior border furrow very shallow. Field of librigena quite flat, sculpture as five to six very faintly raised tubercles vaguely arranged around base of eye socle, and with shallow pits randomly arranged. Precranidial lobe with two or three rows of tubercles.

Rostral plate unknown. Hypostome, only middle body known. Middle body only slightly longer than wide, diamond-shaped in outline, rhyncos projecting forwards as far as anterior border furrow, narrowing rapidly anteriorly. Macula oval in outline, obliquely aligned. Surface very finely granulated.

Thorax of eleven segments. Axis a quarter width of thorax. Central half of axial ring arched forwards, posterior margin transverse. Inner half of pleural field horizontal, outer half flexed down and backwards. Posterior pleural band parallel-sided for horizontal region, increasing markedly in length (exsag.) laterally. All surfaces with very fine granulation.

Pygidium triangular in outline, as wide as long. Pygidial axis a little over three-quarter length of pygidium, one-third width (tr.) of anterior margin, tapering posteriorly almost to a point, only slightly raised above the convexity of the pleural field. Fifteen to twenty axial ring furrows, distinct for full width behind most anterior three or four rings, increasingly effaced medially and laterally posteriorly so that only seen as two rows of transverse slits posteriorly. Up to four, not greatly raised, median tubercles present on axial rings (population not large enough to determine frequency of occurrence). Seven pleural ribs, eighth pair probably fused behind pygidial axis; anterior two ribs with free lateral margins, distal parts of posterior five ribs fused to form posterior border; progressively curving inwards posteriorly, merging into upturned mucro of unknown length. First pleural rib and first axial rib separated by very shallow furrow. All surfaces very finely granulated.

Remarks. E. expansus would appear to be a member of the *E. schmidti* group (Männil, 1968) from West Estonia (Upper Llandovery), in the general characters of the cephalon, including the short genal spine, and the shape and formation of the pygidium. However, *E. expansus* has fewer glabellar tubercles, although the glabellar tubercle formula is quite similar, and tubercles of the fixed cheek which overlap the axial furrow are larger, the eye is longer (exsag.), and the pygidial mucro is shorter. In Scotland *E. expansus* can only be compared with an undescribed encrinurine from the Wood Burn Formation (Fronian), Girvan especially in the form of the elongate glabella, genal spine, and mucronate pygidium. However, the Pentland form can be distinguished by the presence of a 1L ridge, a different glabellar tubercle formula, and the glabellar tubercles being smaller than the glabellar lobes.

Encrinurus pagei (Haswell, 1865)

Plate 81, figs. 5, 8, 9, 10, 12

1865 *Zethus pagei* Haswell; p. 37, pl. 4, figs. 1–3.
?1948 *Cromus*(?) *dris* Lamont, pl. 1, fig. 17 (no description; poor illustration).
?1948 *Cromus* sp.; Lamont, p. 7, pl. 1, fig. 18 (no description; poor illustration).
1948 *Cromus pagei* (Haswell); Lamont, p. 7, pl. 1, fig. 19 (no description).
1978 *Paracalgachia henshawensis* (Lamont); Lamont, p. 271, pl. xxxi, fig. 6 (*nomen nudum*).
1978 *Wallacia expansa* (Haswell); Lamont, p. 271, pl. xxxi, fig. 7.

Figured material. As with *E. expansus*, the types cannot be located, and figured specimens include an almost complete intaglio 25 mm long, RSM GY 1978. 61. 425a, b (internal and external moulds), lacking librigenae (Pl. 81, fig. 10). Partial specimens: —528, 530 (Pl. 81, figs. 12, 9); thoracopygon —529a, b (Pl. 81, fig. 5); cephalon with librigenae, figured by Lamont 1948, RSM GY 1897. 32. 6 (Pl. 81, fig. 8).

Dimensions. Cephalic length (sag.) 6·0–7·5 mm, width (tr.) 16–18 mm.

Distribution. All specimens come from unit E of the Wether Law Linn Formation at NT 148588 on the west bank of the Henshaw Burn when they occur with a fauna of conulariids, bivalves, gastropods, and the brachiopod *Pentlandella.*

Diagnosis. 1L present as large ridge. Lateral glabellar lobes larger than tubercles on glabellar lobe. General tubercle formula: I—1*, 2; ii—0; II—1, 2*; iii—0. Anterior border of cranidium with single row of eleven tubercles. Very short genal spine. Field of fixigena and field of librigena with many tubercles. Pygidium with eight pleural ribs and seventeen axial rings.

Description. Differs from *E. expansus* in the following features. 1L as larger ridge protruding as far as other lateral glabellar lobes but not as swollen. Lateral glabellar lobes as rectangular protruberances overhanging axial furrow, tuberculate. All apodemes shallower. Occipital furrow and 1S separate. 1S, 2S, and 3S deeply impressed extending a little way across glabellar lobe. Preglabellar furrow as very shallow depression. Tubercle formula: I—1*, 2; ii—0; II—1, 2*; iii—0. Anterior border of cranidium with single row of eleven tubercles, one placed sagittally. Longitudinal median glabellar furrow as broad shallow depression. Posterior border of fixigena projecting into very short genal spine. Field of librigena with more, better-defined, tubercles.

Eye not preserved in full detail. Librigena poorly known but considerably more tuberculate; lateral border wide, and possessing a single row of tubercles. Rostral plate and hypostome unknown.

Pygidium slightly wider than long, flattened. Pygidial axis hardly raised above convexity of pleural field, about one-third width of anterior margin; about seventeen axial ring furrows decreasing in definition posteriorly. Pygidial axial furrow deeply impressed anteriorly, shallowing rapidly beyond 4th pleural rib. Median tubercles present on some rings. Eight pleural ribs, anterior four ribs with free lateral margins, posterior ribs fused to form posterior border.

Remarks. This species was very poorly described by Haswell (1865) and is largely unrecognizable from his illustrations. Even so, the horizon given (Locality I) and the associated conulariids mentioned by Haswell indicate that the specimens were collected from unit E, in which this *Encrinurus* species alone occurs; it is therefore considered to be a valid species. *E. pagei* is closest to *E. variolaris* (Brongniart, 1822) from the Wenlock and Ludlow series of the West Midlands and Welsh Borderlands. However, the Pentlands form differs particularly in having a sagittally placed tubercle on the anterior border of the cranidium, 1L continuing as a ridge across the glabella, more pygidial axial rings, and less tuberculate pygidium over all.

Family CALYMENIDAE Burmeister, 1843
Subfamily CALYMENINAE Burmeister, 1843
Genus CALYMENE Brongniart, 1822
Calymene frontosa Lindström, 1885

Plate 79, figs. 3–11

1885 *Calymene frontosa* n.; Lindström, p. 69, pl. 15, figs. 1–4.
?1894 *Calymene frontosa* Lindström; Schmidt, p. 18, pl. 2, figs. 4, 4*a*, *non* figs. 5, 5*a*, 6, 7.
1936 *Calymene frontosa* Lindström; Shirley, p. 387.
1949 *Calymene carlops* sp. nov.; Lamont, p. 319, pl. 18, figs. 13–19.
1970 *Calymene carlops* Lamont, 1949; Schrank, pp. 115, 119.
1970 *Calymene frontosa* Lindström, 1885; Schrank, p. 116, pl. 1, figs. 1, 2.
1977*a* *Calymene frontosa* Lindström, 1885; Männil, p. 244, pl. 2, figs. 1, 2.
1978 *Calymene carlops* Lamont, 1949; Lamont, p. 274.

Types. Lectotype: RM Ar6210, figured Lindström 1885, pl. 15, figs. 1–3, from the Lower Visby Beds (topmost Llandovery), Visby, Gotland. Paralectotype: RM Ar6211, figured Lindström 1885, pl. 15, fig. 4; RM Ar6212—both enrolled specimens from Visby, Gotland.

Figured material. Cranidium Gr I 1518 (figured by Lamont as holotype of *Calymene carlops*, 1949, pl. viii, fig. 15 (Pl. 79, fig. 3); Intaglio GSE 1013–14. (Pl. 79, figs. 6, 7); Cranidia RSM 1978. 61. 537 (Pl. 79, fig. 11), —539 (Pl. 79, fig. 8); small pygidium 540a, b (Pl. 79, fig. 5); pygidium —541 (Pl. 79, fig. 10), —545 (Pl. 79, fig. 9).

Other material. RSM 1876. 42, A, B, C. (Specimens collected by John Henderson and figured by Lamont 1949, pl. XVIII, figs. 16, 18, and 19 as *Calymene carlops*. These are poorly preserved and are not refigured here.) Also RSM GY 1978. 61. 536, —538, —542, and —543.

Distribution. As Lamont (1978) noted this species appears to be confined to unit A of the Wether Law Linn Formation, at NT 145582 and NT 148586. Tipper likewise records this distribution. The only complete specimens known to us are that figured in Plate 69, figs. 6, 7 and a larger specimen in the collection of Mr. Andrew Poland.

Dimensions. The size range of this species is considerable. The figured complete specimen is small, only 9·0 mm long; cephalic length otherwise (sag.) ranges from 3·5 to 10·0 mm and width from 7·0 to 14·0 mm, pygidial width from 3·0 to 9·5 mm.

Diagnosis. Glabella about as wide as long, anterior margin almost transverse. Preocular part of fixed cheek about one-third as wide as glabella at 2L. Anterior border of cranidium rolled. Pygidium strongly convex with six axial rings and five wide pleural furrows. All raised surfaces with irregularly sized and spaced granules.

Description. Cephalon twice as wide as long. Glabella almost as wide as long, anterior margin almost transverse. Occipital ring about four times wider than long medially, decreasing in length laterally to accommodate 1L lobe. 1L a quarter width of glabella, oval in outline. 1S curving backwards and inwards, shallowing posteriorly. 2L half size of 1L, also oval in outline, 2S, as depression between 2L and 3L. 3L as swelling on side of glabella, only slightly shorter (exsag.) than 2L. Shallow anterior pit positioned midway between 3L and anterior margin of glabella. Preglabellar furrow deep and wide, slightly undercutting anterior margin of glabella. Anterior border rolled, slightly longer laterally than medially. Posterior border of fixed cheek lengthening (exsag.) laterally. Posterior border furrow distinct and wide. Palpebral lobe slightly longer than, and positioned opposite, 2L. Preocular part of fixed cheek about one-third as wide as glabella at 2L, narrowing anteriorly; anterior inner corner pointed. Anterior branch of facial suture running forwards to anterior margin. Posterior branch of facial suture running transversely for short distance, then running diagonally backwards crossing posterior margin obliquely. All raised surfaces with irregularly sized and spaced granules.

Librigena subtriangular in outline. Lateral border rolled, wide. Lateral border furrow deep and wide. External surface of librigena with scattered granules. Hypostome unknown.

Thorax of thirteen segments. Axis one-third width of thorax. Articulating half ring about half width of axial ring. Axial ring transverse posteriorly, produced into nodes laterally. Pleural region horizontal for adaxial half, flexed downwards abaxially. Pleural furrow positioned anteriorly on rib, running transversely.

Pygidium roughly triangular in outline. Pygidial axis strongly convex, narrowing slightly posteriorly to blunt point, with six axial rings; axial ring furrows becoming less distinct posteriorly. Axial furrow well-defined. Pleural region deflected downwards so that posterior margins almost transverse; five wide pleural furrows; interpleural furrows more distinct distally. All raised surfaces with scattered granules, pleural furrows with some granules.

Remarks. The Pentland calymenid is considered to be conspecific with *C. frontosa* because of the overall similarity of their exoskeletons, especially in the deep and wide preglabellar furrow, the deep and wide axial furrow in front of lobe 2L, the pointed, projecting anterior corner to the fixed cheek, small palpebral lobe, and the cranidial ornamentation. Lamont (1949, p. 231) considered that the Pentland

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EXPLANATION OF PLATE 81

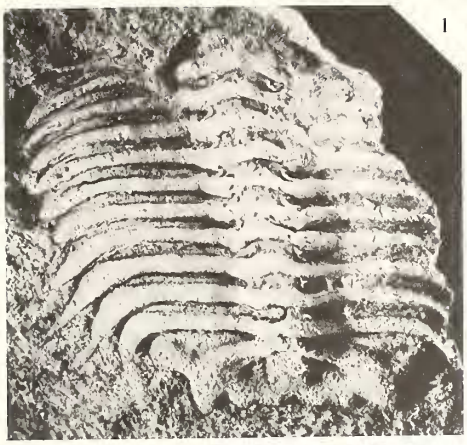
Figs. 1, 3, 4, 11. *Leonaspis lothiana* (Lamont). Quarry near Bavelaw Castle, Bavelaw Castle Inlier (see also Pl. 82). 1. Thoracopygon, latex replica of external mould, RSM GY 1897. 32. 242, ×4·5. 3. Incomplete thoracopygon, latex replica of external mould, Gr. I. 22226, ×7. 4. Damaged cephalon and part of thorax, GSE 13487, ×5·5. 11. Details of ventral morphology, latex replica of external mould, RSM 1978. 61. 520, ×8.

Fig. 2. *Anacaenaspis dealgach* (Lamont). Wether Law Linn Formation (unit A or C). Syntype cephalon, internal mould, RSM GY 1979. 77. 45a, ×8 (see also Pl. 82).

Figs. 5, 8, 9, 10, 12. *Encrinurus pagei* (Haswell). Unit E, Wether Law Linn Formation, Henshaw Burn. 5. Pygidium and last thoracic segments of thoracopygon, latex replica of external mould, RSM GY 1978. 61. 529a, ×3. 8. Flattened cephalon, internal mould, (figured Lamont 1948, pl. 1, fig. 13), RSM GY 1897. 32. 61, ×2. 9. Cephalon lacking librigenae, retaining seven thoracic segments, latex replica of external mould, RSM GY 1978. 61. 530, ×3. 10. Almost complete specimen, latex replica of external mould, RSM GY 1978. 61. 425a, ×2. 12. Cephalon lacking librigenae, with two thoracic segments, latex replica of external mould. RSM GY 1978. 61. 528a, ×2·5.

Fig. 6. *Acernaspis* sp. upper Reservoir Formation. Internal mould, outer surface somewhat recrystallized, RSM GY 1978. 61. 534, ×5.

Fig. 7. *Anacaenaspis* sp. upper Reservoir Formation, Deerhope Burn. Internal mould of cranidium, GSE 13518, ×5·5.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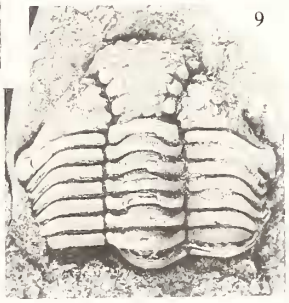
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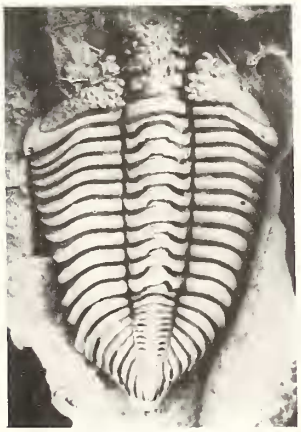
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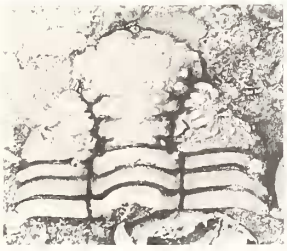
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CLARKSON and HOWELLS, Silurian trilobites

calymenid form could be separated from *C. frontosa* in that it had a less tapering and longer frontal glabellar lobe and possessed finer surface granulation. Study of populations of the Scottish and Gotland forms indicates that these two features vary and are not considered specific differences.

Family PHACOPIDAE Hawle and Corda, 1847
Subfamily PHACOPINAE Hawle and Corda, 1847
Genus ACERNASPIS Campbell, 1967
Acernaspis sp.

Plate 81, fig. 6

1978 *Cyphoproetus* (*Otadenus*) *alacer* Lamont; p. 267, pl. xxx, fig. 12.

Material and remarks. A number of specimens of *Acernaspis*, usually small, have been found in the upper Reservoir Formation, but their preservation is such that no specific determinations can be made. The oldest known are GSE EM 1108/9 from a locality 'in the Gutterford Burn, below the starfish beds'; whose precise horizon is unknown. These are respectively a partially enrolled cephalon with two thoracic segments and a pygidium, both preserved as internal moulds in a red mudstone. Higher in the Reservoir Formation at localities along the Deerhope Burn there have been found two small complete specimens occurring in association with *Encrinurus* fragments and strophochonetids. They are internal moulds with the surface encrusted by silica and little structural detail can be distinguished (RSM GY 1978. 61. 534, 535). There is also a large partially enrolled thorax (GSE EM 1230) and a pygidium (GSE EM 1268). It is probable that all those from the Upper Reservoir Formation belong to the same species, but their preservation does not permit more detailed analysis.

Subgenus ESKASPIS (Clarkson, Eldredge and Henry, 1977)
Acernaspis (*Eskaspis*) *sufferta* (Lamont, 1947)

Plate 79, fig. 12

1947 *Eophacops sufferta* n. sp. Lamont, p. 6, pl. 1, figs. 21, 22.
1977 *Acernaspis* (*Eskapsis*) *sufferta* (Lamont, 1947); Clarkson *et al.*, p. 126, pl. 18, figs. 1–9; pl. 19, figs. 1–7, text-figs. 2*a*, *f*, 3*a*, *b*, 4*a*, *c*.

Material. A single phacopid hypostome, consisting of a partial external and complete internal mould, RSM GY 1978. 61. 510a, b, from unit A, Wether Law Linn Formation at NT 148586, probably belongs to *A.* (*Eskaspis*) *sufferta*. The moulds are somewhat distorted, fragile, and only lightly impressed on the matrix, and the anterior border is slightly abraded.

Description. Hypostome about as broad (to tips of wings) as it is long (sag.) Anterior border nearly straight, curving posteriorly at the wings. Central body about two-thirds total width of hypostome, weakly convex medially, and declining laterally and posteriorly. Faint lateral swellings (? maculae) present half-way down its length. Anteriorly central body defined by broad, shallow anterolateral furrow turning in from lateral border at its deepest point.

Hypostomal border parallel-sided and in plan almost horizontal, not quite reaching the anterior border, and projecting outwards anteriorly as a flange. Border abruptly changes course at about half-way along its length, where the hypostome is deepest, sloping posteriorly at about 45° to the horizontal curving inwards to form the elliptical posterior border. Hypostomal wings broadly triangular and (in plan) sloping forwards at some 45° to the horizontal.

Surface sculpture of closely spaced granules, just like those on the dorsal surface of the cephalon.

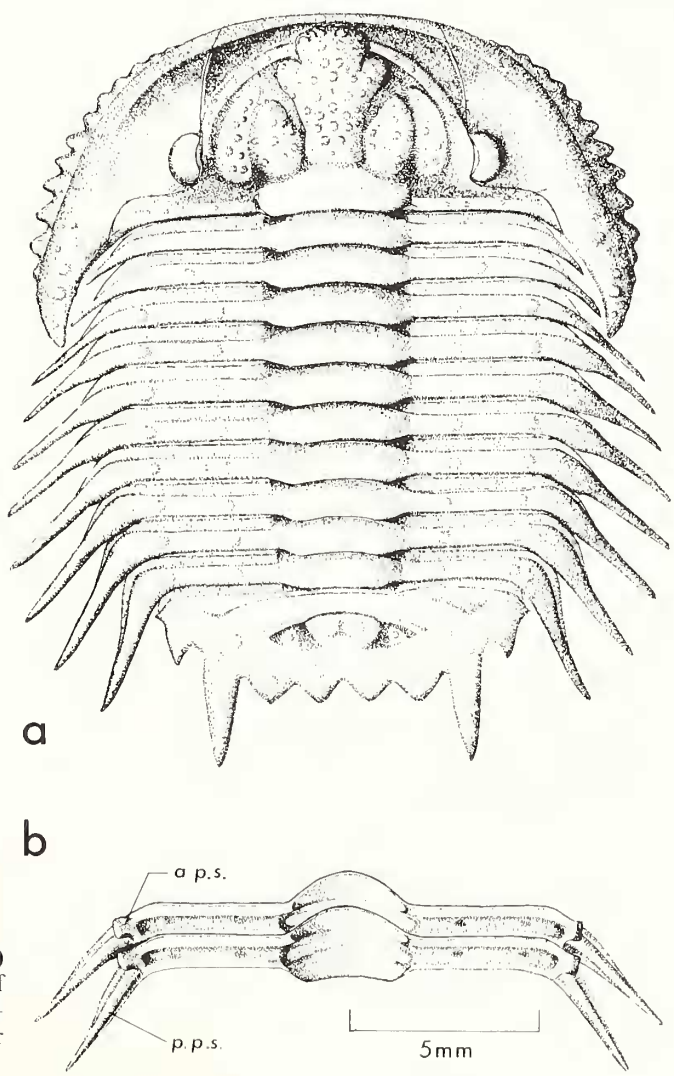
Remarks. Very few hypostomes of Llandoverian Phacopina have been described. Campbell (1967) noted that the hypostomes of *Acernaspis* and *Eophacops* were then unknown, but described and figured that of *Ananaspis communis* (Barrande) (ibid., Pl. 13) which has a 'short posterior border, and ornament of granules and is strongly tapered'. Männil (1970*a*) figured the hypostome of *Acernaspis konoverensis* (ibid., fig. 1*a*, *b*, Table 1, fig. 9) with its posteriorly curved anterior border and (1970*b*, fig. 1*a*, *b*, Table 2, fig. 9) that of *A. rectifrons*, both of which bear some similarity to that of *A.* (*E.*) *sufferta*, though the wings of the latter are broader and the posterior border more pronounced.

Family ODONTOPLEURIDAE Burmeister, 1847
Genus LEONASPIS Richter and Richter, 1917
Leonaspis lothiana (Lamont, 1948)

Plate 81, figs. 1, 3, 11; Plate 82, figs. 5, 7-10; text-fig. 2*a*, *b*

1899 *Acidaspis* sp. Peach and Horne, p. 605 (list only).
1947 *Acidaspis* aff. *erinaceus* Marr and Nicholson; Lamont, p. 290 (list only).
1948 *Acidaspis lothiana*; Lamont, pl. 1, figs. 6, 7.
1978 *Dudleyaspis lothiana* (Lamont, 1948, *pars*); Lamont, p. 276, pl. xxx, fig. 21.

Figured material. Lamont (1948) illustrated this species, the only odontopleurid, and the only common trilobite in the Bavelaw Inlier, by a small photograph of an articulated thorax and pygidium, and another showing a cephalon in frontal view. These two syntype specimens are no longer available but in 1978 Lamont illustrated (GSE 13487) a damaged partial external mould, originally from the Hardie collection. This is refigured here (Pl. 82, fig. 4); other figured material includes a thoracopygon, Gr I 22226 (Pl. 81, fig. 3); an external mould of the



TEXT-FIG. 2 *a*. *Leonaspis lothiana* (Lamont) Reconstruction. *b*, Ventral morphology of thoracic segments; reconstruction. (a.p.s.—anterior pleural spine; p.p.s.—posterior pleural spine.)

ventral surface, RSM GY 1978. 61. 520 (Pl. 81, fig. 11); a pygidium with moulds of both surfaces, and thoracic segments on the same slab, RSM GY 1978. 61. 522. 3 (Pl. 82, figs. 5, 6); a partial cranidium, —518 (Pl. 82, fig. 8); and a slab with an enrolled specimen and another largely complete specimen, —517 (Pl. 82, figs. 9, 10).

Other material. An abraded intaglio, RSM GY 1897. 32. 242; and various fragmentary specimens, RSM GY 1978. 61. 518–521.

Distribution. This species does not occur in the North Esk Inlier and is known only from a small quarry near Bavelaw Castle (NT 168627, locality 2 of Mykura 1975). It is presumed that these beds are of Upper Llandovery age, but their precise horizon is unknown.

Dimensions. Total length (estimated average) 15 mm, width 13 mm. Cephalic length (average) including spines 6 mm, width 11 mm, glabellar length 2·5 mm, pygidial length 2·5 mm, width 5·5 mm.

Diagnosis. Leonaspis with short, blunt genal spines, posterior thoracic spines with swollen bases, increasing in length and inclination posteriorly, and pygidium with two short outer pairs of spines, one pair of major thoracic spines enclosing four short pairs of spines all of equal length.

Description. All known specimens are incomplete, and the description and reconstruction are composite and based upon several specimens with measured parameters.

Exoskeleton longer than broad by a factor of five-sixths, circumference round spine tips subelliptical verging on quadrate. Cephalon broad (tr.) semi-elliptical in outline, in plan view somewhat flattened anteriorly, maximum width just anterior to tips of genal spines, twice sagittal length including genal spines, three times length to edge of occipital ring.

Cranidium with large smooth occipital ring, devoid of occipital spine, occipital furrow distinct though rather shallow medially, but becoming deeply marked posterior to the basal glabellar lobes (1L) where the occipital ring is laterally indented. Glabella at maximum width (just anterior to the eye) about as wide as it is long with more or less rectangular median anterior glabellar lobe which is rather flat-topped, declining anteriorly to deep anterior furrow. 1L large, half total glabellar length and nearly twice as long (sag.) as wide, slightly pointed anteriorly, with its axis about 25° to the sagittal plane. 1L bounded anteriorly but shallowing and narrowing inwards and backwards, where it joins (normally) broad and rather poorly defined axial furrow. 1L steepest postero-laterally where it becomes nearly vertical. 2L small (one-fifth total length of the glabella), rounded, of similar convexity to 1L, bounded sagittally by a very weak axial furrow which is a sagittal extension of that bounding 1L. Large curving fixigenal area running forward from behind 1L, forwards and inwards to connect with 2L across a broad shallow furrow directly anterior to 1L. Very deep furrow separating this area from high palpebral lobe which continues forward opposite the centre of 1L as slender continuously curving ocular ridge, in its median part about 45° to the sagittal plane. Anterior border furrow very deep, anterior border high, with a flat upper surface, rounded in plan but somewhat flattened anteriorly, curvature increasing postero-laterally. Palpebral lobe opposite posterior edge of 1L, approximately one-third the length of the glabella. Anterior branch of facial suture initially parallel with sagittal line just in front of eye, but curving slightly inwards anteriorly. Posterior branch in transverse plane, and parallel to posterior border, which forms a low, flat, transverse ridge, lower than occipital ring, truncated by posterior branch at a distance from occipital ring slightly greater than width of occipital ring itself.

Librigena triangular with rather blunt and stout genal spine less than one-third of total length, eye conical, with very small lenses visible on visual surface, no eye socle, but eye separated from smooth, steeply sloping librigenal surface by very poorly defined junction. Lateral border furrow deep and clearly defined anteriorly, shallowing backwards and merging with posterior border furrow. Lateral border forming strong curving ridge merging posteriorly with genal spine. Beneath this border are fourteen short, stout spines inclined outwards at some 15° from the vertical, increasing in size posteriorly, the largest opposite posterior border and with the two smaller spines directly below the anterior curve of genal spine. Librigenal doublure extending inwards to the level of the lateral border furrow.

Cranidium (glabella, glabellar lobes, ocular ridges, and fixigena) sculptured with rounded granules, more or less symmetrically placed, spaced more widely than their diameter, slightly larger and more clustered on anterior glabellar lobe. Numerous large granules are also present towards the point of the genal spine. Cephalon otherwise smooth other than a few small granules on occipital ring, and dense granulation on antero-lateral border and denticles of librigena. Hypostome unknown.

Thorax of ten segments, with broad convex axis about a quarter of total width, and with pronounced articulating half ring about same length (sag.) as the axial ring. Axis parallel-sided, slightly narrowing posteriorly. In ventral view a pair of slightly raised platforms, with rounded ends directed outwards are visible

within axial ring, just posterior to flat and poorly defined apodemes (text-fig. 2*b*). Principal pleural ridge broad, flat-topped continuous with posterior pleural spine; anterior pleural band broad (exsag.), flat, depressed, terminating in backwardly curved edge laterally; posterior pleural band narrow (exsag.), depressed, fulcrum swollen with single large tubercle which becomes more pronounced with each succeeding posterior pleura. Anterior pleural spine, short in ventral view, rectangular, and blunt ended; inclined outwards at angle of some 45° to sagittal plane. Posterior pleural spine thin, straight, and sharply pointed, becoming much longer and more highly inclined to transverse plane posteriorly, with angles ranging from 40° at front to 80° at rear.

Pygidium (exclusive of spines) three times as broad (tr.) as long, with two-ringed rhachis. Axial furrow of first ring barely perceptible, second ring sharply marked off, rounded posteriorly with pair of large swellings, and with short transverse groove behind, surrounded by deep transverse boat-shaped depression. Articulating half-ring highly convex with deep articulating furrow behind; one pair of apodemes below, for ventral surface. First axial ring joining with strong flat pleural ridge, curving backwards to meet pronounced broad posterior border, opposite point of origin of major (second pair) posterior spine, with which, however, it is not directly connected. Posterior border flat, over one-third width (sag.) of pygidium. Five pairs of pygidial spines; anterior pair very short, directed slightly forwards, and probably homologous with anterior pleural spine of the thorax (cf. Whittington 1956, p. 509); second pair short and pointed; third pair strong major pygidial spines, same length as pygidium (sag.), twice as thick as posterior pleural spines at rear of thorax, and slightly swollen just behind their bases; between these four short, broad-based, rather blunt spines, set in transverse plane, and all of similar size and shape. Doublure forms broad flange turned inwards as far as posterior border furrow, with slightly raised transverse band, narrowing antero-laterally, and inclined forwards terminating in small anterior spine. Dorsal surface of pygidium with large tubercle on border, anterior to base of major spines, and on four median spines. Ventral surface of pygidium and spines densely granulated, this granulation is present on sides of spines but dies out dorsally.

Remarks. L. lothiana is close to *L. marklini* (Angelin) from the Upper Wenlock–Lower Ludlow Halla and Mulde beds of Gotland, especially in the form of the glabella, though it is relatively smaller in *L. lothiana*, and in the short and stumpy genal spine. The pygidial spines of *L. marklini* are relatively longer and the swollen bases of the thoracic spines are less pronounced. Bruton (1967) has listed the characters whereby *L. marklini* is distinguished from other species.

Leonaspis sp.?

Plate 82, fig. 6

Material. A single small pygidium, RSM GY 1978. 61. 516, of width 3·5 mm, preserved as an internal mould was found at NT 145582 in the Deerhope Burn at the boundary of the Deerhope and Wether Law Linn Formations.

Description. Pygidium (including spines) about as broad as long, semicircular with broad subparallel-sided rhachis one-third total width with three axial rings. Three pairs of rather slender marginal spines. Outer pair short, curving slightly adaxially; middle pair longer, about half total pygidial length, straight directed slightly adaxially; internal pair continuing line of axial furrows, shorter and not reaching so far posteriorly, almost parallel with axis. Large tubercle located on pleural field near base of each middle spine; pair of smaller tubercles lie just within axial furrows in front of third segment of rhachis.

Remarks. This pygidium cannot be matched with that of any known Silurian species. *L. deflexa* (Lake, 1896) has a somewhat similar though narrower pygidium and that of *L. angelini* (Prantl and Přibyl) (Bruton 1967, pl. 34, fig. 4) also resembles that of the Pentland species though the spines are much longer. Until further material is forthcoming the species is left under open nomenclature.

Genus ANACAENASPIS Bruton, 1967

Anacaenaspis dealgach (Lamont 1978)

Plate 81, fig. 2; Plate 82, figs. 1–4; text-fig. 3

1948 *Acidaspis dealgach* Lamont, p. 5, pl. 1, figs. 8, 9 (no description; poor illustration, *nomen nudum*).
1978 *Bruxaspis dealgach* (Lamont 1948) [*sic*]; Lamont, p. 275, pl. xxx, figs. 19, 20 (poor illustration).

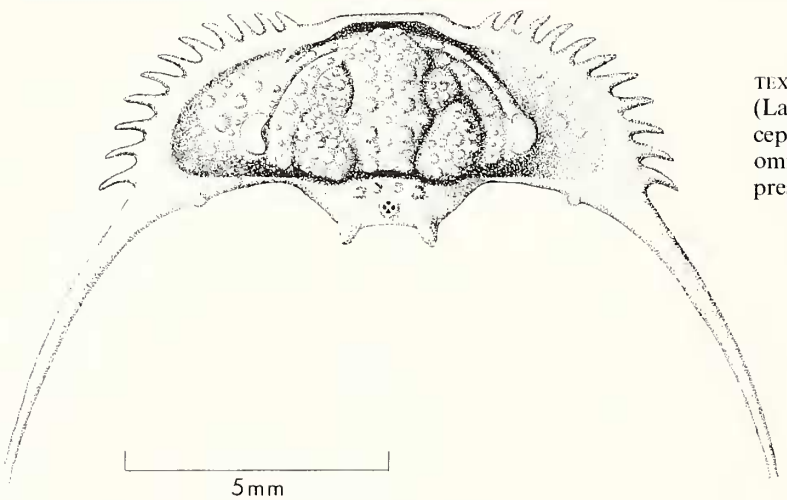
Material and distribution. The syntypes are two specimens figured by Lamont (1948) and later sketched (1978). One of these is a partial cephalon, (internal mould) RSM GY 1979. 77. 452, the other a pygidium devoid of spines

which is poorly preserved and is not figured again here. These are recognizably the same as four specimens collected by J. C. Tipper from unit A of the Wether Law Linn Formation at NT 148586, RSM GY 1978. 61. 512 (Pl. 82, fig. 2), a largely complete internal mould of a cephalon, two incomplete external cephalic moulds, RSM GY 1978. 61. 513 and 514 (Pl. 82, figs. 1, 3), and an almost complete internal mould of a pygidium, RSM GY 1978. 61. 515 (Pl. 82, fig. 4), which represent all the available material.

Dimensions. Cephalic length exclusive of genal spines approximately 4 mm, breadth 10 mm. Pygidial width approximately 7 mm.

Diagnosis. Small *Anacaenaspis* with subtrapezoidal glabella, long curving genal spines, eleven pairs of lateral spines, rather elongate glabella with constricted base, and relatively large 1L and 2L. Occipital ring broad with two small occipital spines. Pygidium with five pairs of symmetrically spaced spines, all of equal lengths.

Description. Cephalon (exclusive of genal spines) subtrapezoidal, some two and a half times broader (tr.) than long (sag.). Occipital ring trapezoidal, three times longer than broad anteriorly, decreasing posteriorly to half anterior width, with pair of short, stout occipital spines directed slightly outwards from posterior angles. Occipital furrow sharply incised. Glabella twice as long as broad, parallel sided but indented by 1L and 2L, subpentagonal anteriorly, descending steeply anteriorly and almost reaching anterior border. 1L very convex, half length of glabella, axis parallel with basal glabellar furrow, some 25° to the sagittal plane, indenting glabella quite distinctly. 2L ovoid, half length of 1L, separated from 1L by strong axial furrow, shallowing posteriorly.



TEXT-FIG. 3. *Anacaenaspis dealgach* (Lamont). Reconstruction of cephalon; course of facial suture omitted since it is not visible in the preserved material.

EXPLANATION OF PLATE 82

Figs. 1–4. *Anacaenaspis dealgach* (Lamont). Wether Law Linn Formation, unit A, at Wether Law Linn (see also Pl. 81). 1. Partial cephalon, fronto-dorsal view, latex replica of external mould, RSM GY 1978. 61. 513, ×8. 2. Cephalon, internal mould showing genal spine, RSM GY 1978. 61. 512, ×8. 3. Partial cephalon, dorsal view, RSM GY 1978. 61. 514, ×8. 4. Pygidium, internal mould, RSM GY 1978. 61. 515, ×8.

Figs. 5, 7–10. *Leonaspis lothiana* (Lamont). Quarry near Bavelaw Castle, Bavelaw Castle Inlier (see also Pl. 81). 5. Pygidium, ventral view, latex replica of external mould and two thoracic segments, RSM GY 1978. 61. 522, ×6. 6. Pygidium dorsal view, latex replica of external mould, RSM GY 1978. 61. 523 (counterpart of 522), ×6. 7. Partial cranidium, latex replica of external mould, RSM GY 1978. 61. 518, ×8. 9. Enrolled specimen, latex replica of external mould. RSM GY 1978. 61. 517 (i), ×5. 10. Partial cranidium, thorax, and detached librigena on same slab, RSM GY 1978. 61. 517 (ii), ×5.

Fig. 6. *Leonaspis* sp. internal mould of pygidium from junction of Deerhope and Wether Law Linn Formations, Deerhope Burn, RSM GY 1978. 61. 516, ×8.

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2

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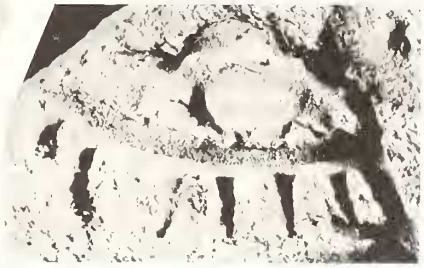
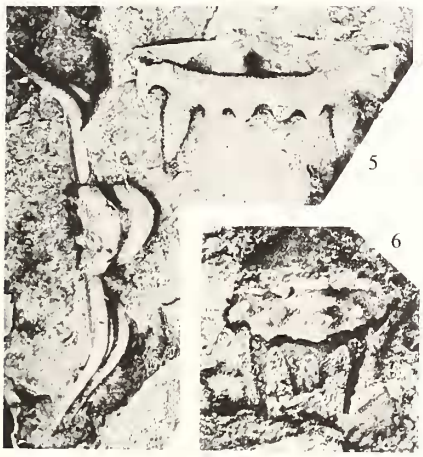


4



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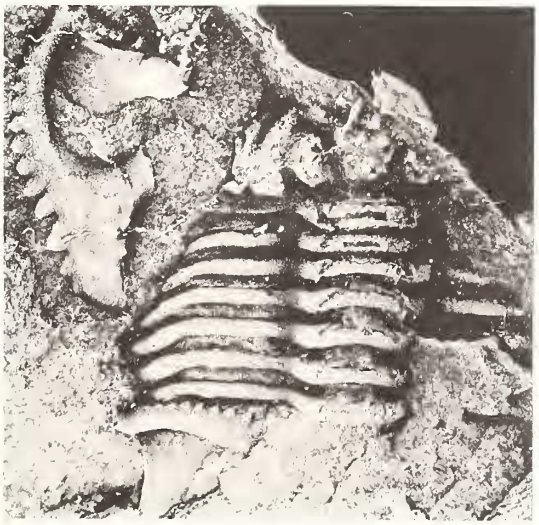

10

CLARKSON and HOWELLS, Silurian trilobites

Fixigena ridge-like swollen, bounded externally by very narrow ocular ridge emerging from front of eye at some 30° to sagittal plane, curving in forwards to run almost transversely and finally terminating against the glabella. Eye about one-third length of glabella, set opposite centre of 1L. Genal field broad, sloping outwards to broad and deep border furrow. Anterior border narrow and straight, reflexed at corners to join broad antero-lateral border, which has eleven radial spines, projecting some 45° to vertical, equally spaced and all of about the same length, with last three directed posteriorly. Sutural ridge emerging from inner edge of lateral border opposite first radial spine running subparallel to, and close to, ocular ridge for short distance, tapering posteriorly and dying out on genal field.

Posterior border narrowing abruptly towards the occipital ring, being very thin just outside 1L. Genal spine very long, broadest at base, becoming slender posteriorly, continuously curving, full length unknown, but at least one and a half times length of cephalon.

Surface sculpture of larger and smaller granules, more or less symmetrical and finer granulation. Glabella with a sagittal line of small granules, and five pairs of large tubercles outside this running parallel with it; with many smaller tubercles. 1L and 2L densely covered with many somewhat smaller tubercles. Row of large tubercles running along fixigenal ridge; genal field with other large tubercles; borders with few ill-defined tubercles, with large pair lying on posterior border. Occipital ring with four tubercles of intermediate size in transverse plane, single median occipital tubercle has four symmetrical depressions. Hypostome and thorax unknown.

Pygidium known only from internal moulds, three times broader (tr.) than long, axis quite broad, rounded posteriorly (but not well preserved in available specimens), first axial ring very pronounced, with pleural band extending postero-laterally to cross flat pleural field. Postero-lateral border well-defined with five symmetrical pairs of nearly straight spines extending subradially, equally spaced, and all about half axial length of pygidium.

Remarks. This species is very similar to *A. emarginata* (Schmidt, 1885) from the Upper Wenlock of Estonia, redescribed by Bruton (1967, p. 237), differing mainly in the relatively longer glabella with its more constricted base, and the somewhat larger 1L and 2L. The axis of 1L in addition is about 25° to the sagittal plane rather than nearly parallel to it as in *A. emarginata*.

Anacaenaspis cf. *dealgach* (*Lamont*)

Plate 81, fig. 7

Remarks. A single incomplete internal mould of a cephalon GSE 13518, which was collected from the uppermost Reservoir Formation, in the Deerhope Burn bears a close resemblance to *A. dealgach*, but the cephalon is less broad, the pleural field especially being narrower. No more precise definition is possible.

Family LICHIDAE Hawle and Corda, 1847
Subfamily CERATARGINAE Tripp, 1957
Genus HEMIARGES Gürich, 1901
Hemiarges rolfei Lamont, 1965

Plate 79, figs. 13–15.

1904 *Lichas* (*Corydocephalus*) *anglicus* (Beyrich), 1846; Reed, p. 95.
1961 *Hemiarges* sp.; Lamont (*in* Rolfe, p. 252) (list).
1965 *Hemiarges rolfei* Lamont, p. 33, pl. 5. figs. 1, 1A.
1965 *Hemiarges* sp.; ibid., p. 34.
1965 *Hemiarges lughmacdiarmidi* Lamont; ibid., p. 34.
1977 *Hemiarges rolfei*; Clarkson *et al.*, p. 121 (list).
1978 *Hemiarges hendersoni* Lamont; Lamont, p. 275, pl. xxx, figs. 17, 18.

Holotype. BU 1896, incomplete internal mould of cranidium with counterpart, figured Lamont 1965, pl. 5, figs. 1, 1A; from the Ree Burn Formation (*crenulata* Zone), Hagshaw Hills, Scotland.

Figured material from Pentland Hills. Internal mould of cranidium figured by Lamont (1978, pl. xxx, fig. 17) as type of *Hemiarges hendersoni*, RSM GY 1979. 45. 2 (locality unknown) (Pl. 79, fig. 13); partial pygidium, part and counterpart RSM GY 1978. 61. 511a, b (Pl. 79, fig. 14); hypostome, part and counterpart Gr. I. 40. 306, 308 (Pl. 79, fig. 15).

Other material. Partial pygidium (internal mould), Gr. I. 40. 307.

Distribution. All known specimens other than the cranidium come from the Upper Deerhope Formation at NT 145582. The species also occurs in the Ree Burn Formation in the Hagshaw Hills and in the Knockgardner Formation at Girvan together with *Podowrinella straitonensis* (Lamont) and *Encrinurus* fragments.

Diagnosis. Cranidium not greatly convex. Frontomedian lobe parallel-sided for most of length (sag.). Bullar lobe small, rounded anteriorly, pointed posteriorly. 1L long (exsag.), greater in length laterally than bullar lobe. Pygidium with long (sag.) tapering axis. Posterior raised ridges of pygidial pleura and border of pygidium with short, pointed spines.

Dimensions of holotype. Cranidial sagittal length, 5 mm; half cranidial width, 3 mm.

Description. Cephalon known in the Pentland Hills only by a single laterally compressed glabella. Whilst this was taken by Lamont as the type of *H. hendersoni* it compares with better-preserved material from Knockgardner in all aspects save the convexity, imparted by lateral compression. Frontomedian lobe parallel-sided for most of length expanding anteriorly to three times midlength width. Longitudinal furrow deep. Occipital ring one and a half times as wide as base of frontomedian lobes. Occipital lobe not preserved. Occipital furrow, shallower than longitudinal furrow, transverse behind frontomedian lobe. Bullar lobe circumscribed, approximately one-third length (exsag.) of cranidium, equal in width (tr.) to narrowest part of frontomedian lobe; kidney-shaped in outline, with small indentation at midlength adjacent to longitudinal furrow, rounded anteriorly, pointed posteriorly. 1L delimited from frontomedian lobe by shallow depression, somewhat inflated. Fixed cheek, palpebral lobe, anterior border and facial suture not preserved. All convex surfaces with irregular, scattered tubercles. Librigena unknown.

Hypostomal outline forms an equidimensional hexagon. Middle body very gently convex, more than three-quarters total width of hypostome, about one and a half times wider (tr.) than long (sag.), expanded anteriorly into large transverse lobes occupying two-thirds its total length, sharply indented behind these and tapering posteriorly to smaller pair of transverse lobes. Middle furrow transverse, quite broad and deep, defining a distinct narrow transverse ridge half total width of hypostome, and separated from posterior border by narrow and deep posterior furrow. Postero-lateral borders flat, about as wide as a quarter of total length of hypostome, and arising just in front of median transverse plane. Thorax unknown.

Pygidium approximately one and a half times wider (tr.) than long (sag.). Axis tapering gradually posteriorly to half axial anterior width (tr.), anteriorly with five distinct axial rings with two more faintly defined rings behind, terminating bluntly but merging into postaxial ridge. First and second lateral pleurae with raised posterior borders produced into short pointed spines. Faintly raised border produced into short spines. Some symmetrical arrangement of granules on axis but not clearly defined, remainder of pygidium with scattered granules.

Discussion. The parallel-sided frontomedian lobe and long 1L, and the pygidial morphology indicate that the Pentland form is identical to *H. rolfei* from the Hagshaw Hills and Knockgardner. *H. huglmacdiarmidi* Lamont (1965, p. 34) from the Knockgardner locality appears to be a *nomen nudum* as no description, type specimen, or type locality is given for this species and no prior reference to it has been traced. The cranidium referred to by Reed (1904, p. 95) cannot be traced. The spinosity of the pygidium of *H. rolfei* separates it from the other *Hemiarges* species found in older rocks of the Girvan Inlier.

FAUNAL AFFINITIES

The Reservoir and Deerhope Formations contain trilobites which appear to be endemic to the Midland Valley of Scotland, whereas the closest affinities of the Upper Llandovery trilobite faunas of the Wether Law Linn Formation are found in the East Baltic (Gotland and Estonia), and the faunas do not resemble those of the Girvan area. Following Schmidt's classic work (1881–1907), and that of Lindström (1885), Öpik (1937), and others, many of the Silurian faunas have been described in detail by Männil (1958; 1968; 1970*a*, *b*; 1977*a*, *b*, *c*) who has given full stratigraphic detail; and both morphological and stratigraphic parallels with the faunas from the Pentland Hills are close. Several successive species of *Acernaspis* in the Llandovery of Estonia show morphological changes in the vincular furrow. Männil (1970*b*, p. 34) notes that early Llandoverian species have a continuous

vincular furrow (*A. semicircularis*, *A. estonica*), whereas by Middle Llandovery times the furrow was becoming faint anteriorly (*A. rectifrons*, *A. incerta*), and by the Upper Llandovery the vincular furrow is absent anteriorly (*A. konoverensis*). A parallel reduction in the anterior part of the vincular furrow is apparent in the Scottish species of *Acernaspis* though the stratigraphic section is less complete than in Estonia (Clarkson *et al.* 1977): *A. konoverensis* is in any case closely similar to *A.* (*Eskaspis*) *sufferta* and would seem to belong to the same subgenus.

Almost all the other trilobites in the Wether Law Linn Formation likewise seem to belong to species groups which are well-established in the East Baltic, especially in the Fronian–Telychian Adavere stage of Estonia. Thus the Pentland *Encrinurus expansus* belongs to the *E. schmidti* group, *Proetus* (*Lacunoporaspis*) sp. resembles the Baltic species *P.* (*L.*) *obconicus*, and *Calymene frontosa* is present both in the Pentland Hills and in Estonia. *Youngia douglasi* has perhaps its closest counterpart in *Y. inermis* and *Y. globiceps*, poorly known species from Gotland, whilst, the odontopleurid *Leonaspis lothiana* is close to *L. marklini* and *L. mutica* from Gotland; *Anacaenaspis dealgach* resembles *A. emarginata*.

Youngia does not seem to occur in Estonia. The Estonian Upper Llandovery faunas are more diverse, including trilobites of the families Scutelluidae and Illaenidae which are absent in the Pentlands, and a richer fauna of Encrinuridae and Calymenidae. Faunas in other parts of Britain and Ireland are quite different. This suggests an extension of open marine conditions between eastern Scotland and the Baltic area in Upper Llandovery times.

The presence of well-preserved phacopid and encrinurid specimens in the Silurian rocks of Ringerike, Norway, has been kindly brought to our attention by M. P. A. Howe and Dr. J. H. McD. Whitaker, who have let us borrow their collections. In Stage 8A (lowermost Wenlock) (Kiaer 1908; Whitaker 1977) occurs a phacopid species virtually indistinguishable from *A.* (*Eskaspis*) *sufferta* and an *Encrinurus* very close to *E. expansus*. Such faunal similarities again reinforce the likelihood of an open marine connection between eastern Scotland and Balto-Scandia during this part of the Silurian, whereas there may have been a physical or ecological barrier between eastern and western Scotland at this time.

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